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THE BOOK ONLY

SPORTING AMONG THE FRACTO-CUMULI
UNDER A CEILING OF CIRRI

THE BOOK OF THE SKY

A Résumé of Personal Experience and Observation

BY

M. LUCKIESH

Director of Applied Science, Nela Research Laboratories, National Lamp Works of General Electric Company

AUTHOR OF "COLOR AND ITS APPLICATION," "ARTIFICIAL LIGHT, ITS INFLUENCE UPON CIVILIZATION," "VISUAL ILLUSIONS," "ULTRAVIOLET RADIATION," ETC.

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DEDICATED

TO THE MEMORY OF

PROFESSOR S. P. LANGLEY

AND OTHERS WHO LED THE WAY TOWARD

THE MASTERY OF THE AIR,

IN APPRECIATION OF THIS WONDERFUL HERITAGE.

FOREWORD

THIS little volume grew out of experiences in flying which have greatly augmented the author's interest in the aerial world. The beauties, wonders, awesome spectacles, inspiring panoramas, and extensive ranges of vision which await the aerial traveler, make of cloudland a veritable fairyland if he will open his consciousness to them. Aircraft have brought this new world of experiences within easy reach of mankind and it is one of the aims of this volume to awaken those who fly, or would fly, to the variety of interest which air-travel affords.

Furthermore, the sky holds much of interest for the earthly observer who will overcome his indifference to this aspect of Nature. Cloudland is full of variety. It is a wonderland of clouds, weather, winds, sunsets, dawns, twilights, and other interesting phenomena. It will brighten many dull moments and may be depended upon at all times to arouse the imagination and to supply something for the lover of beauty. Those who would be interested technically will find an abundance of interest in the phenomena of the atmospheric ocean above. Therefore, broadly, the aim of this volume is to aid the general reader in becoming more interested in cloudland.

In aiming to present the discussions in a readable manner, tedious technical data have been reduced to a minimum. Such material has been grouped largely in a few chapters although technical facts have been interspersed throughout the chapters with the hope that they would be more palatable to the general reader in this manner of presentation. Clouds are conspicuous

in some of the chapters because they are of great importance in revealing the winds and in foretelling the weather; besides they provide much of the variety and beauty of the sky. The author is unaware of any modern volume which discusses clouds for the general reader. For this reason several chapters have been devoted to clouds in order that the earthly observer and the aerial traveler may learn to know them intimately and may become familiar with their meanings. They become such a dominating part of the sky that as one becomes fully appreciative of this aspect he finds a cloudless day rather uninteresting and if he is an aerial traveler he yearns for that fairyland which clouds make of the aerial world.

Since the advent of flying with its modern safety, convenience, and extensive possibilities, the aerial world becomes more important and interesting to mankind. It is believed that this little volume, which touches upon so many aspects of the sky and upon what may be seen and felt in cloudland, will interest the general reader whether he is one who flies in reality or would fly on the wings of his imagination or would be content merely to admire the sky and to learn its meanings.

By intermingling the two viewpoints, namely, that of the earthly observer and that of the aerial traveler, it is believed the wonders of cloudland become more easily visualized, recognized, and understood. By combining with this plan a popular treatment throughout, it is hoped that this little volume will be entertaining and instructive to the general reader as well as to those who have a more specific interest in the sky and in the aerial world.

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CHAPTER I

MAN UNSHACKLED

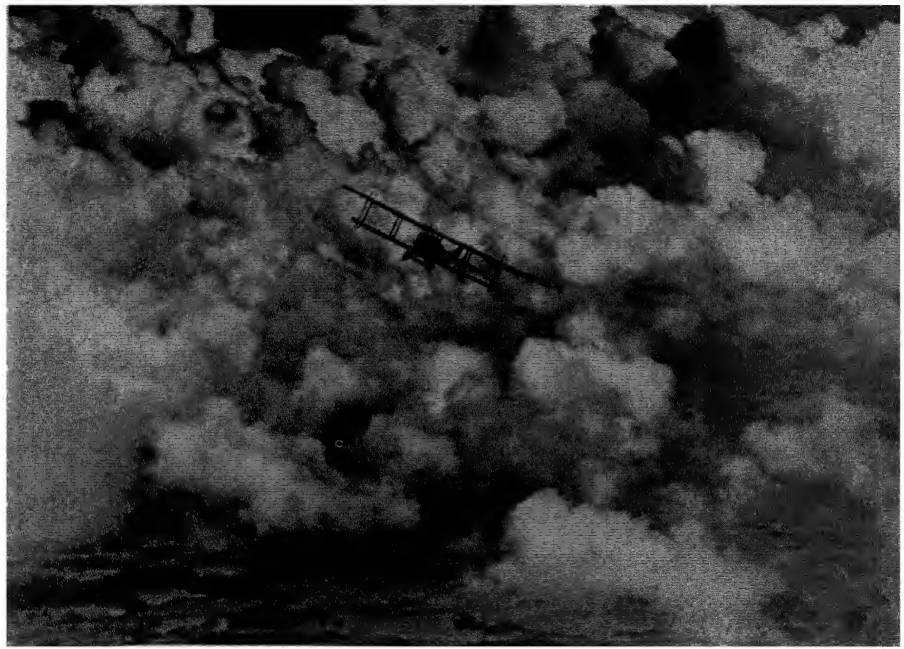
"Here the free spirit of mankind, at length
Throws its last fetters off; and who shall place
A limit to the giant's unchained strength,
Or curb his swiftness in the forward race?"
—BRYANT.

ON all sides Nature presents to searching eyes a continuous warfare in which no quarter is asked and none is granted. The lowliest plants and animals battle against tremendous odds for their existence and the survivors among wild life are as a whole those best fitted to struggle against their hostile environment. A glimpse of this fundamental aspect of Nature which appears to result, at least when narrowly viewed, in an extreme wastefulness and a high mortality among the forms of life wholly at the mercy of Nature's whims, alleviates in some slight degree the horror of warfare among men who have broken to some slight extent the shackles of utter subserviency to Nature.

Man's early history is but a repetition of the history of the jungle. He fought his kind as other animals in order to survive, but he early began to triumph little by little over Nature. In order to *exist* he had merely to be victor in those encounters which were forced upon him. In order to *progress* he had to become the aggressor and to carry his warfare into many realms which for bare existence could be shunned.

Material progress may be measured in terms of man's independence of or triumph over Nature. Let the imagination drift back through the vista of centuries into the remote periods of unrecorded history and note the myriads of minor and major victories of mankind which have led gradually toward emanicipation from the bondage of Nature. Natural laws still exist but mankind has learned many of their secrets with the result that he utilizes them against each other to his advantage. In other words, intellect has harnessed many of these laws so that they do man's bidding.

A fundamental of the growth of mankind is progress. It is apparently an obsession but likely it is a fundamental of the scheme of Nature. Daily, hourly, and even momentarily, along the battle-area of progress which covers our earth, scouting parties are out and minor skirmishes are taking place. These pave the way for occasional triumphs of tremendous import. The scales are always tilting more and more in man's favor, but these triumphs are not gained without sacrifice.



IN THE FAIRYLAND OF CLOUDS

Countless lives are dedicated to progress; some through momentary risks and many through a lifetime of slavery and often of suffering, ignored or even persecuted by the multitude, but impelled and sustained by that creative spirit which demands discoveries from the scientist and applications of these from the inventive genius.

With ever-increasing momentum science has added triumph after triumph until the present generation complacently accepts epoch-making developments. Many of these developments touch the multitude only indirectly though the multitude is benefited by them. The masses are not sufficiently imaginative to be thoroughly inspired by scientific achievements unless they are directly in touch with them. To hear and to recognize the voice of a friend a thousand miles away by the electrical impulses transmitted by telephone wires is perhaps much more thrilling to the average person than to receive a wireless message transcribed by a third person. Both are triumphs over Nature but to the masses the former is more vivid. To the scientist the latter is the greater achievement. Scientific protection from deadly microscopic organisms does not impress the average individual as much as an iron grating which confines the hungry lions in the cage before him. But in the last analysis, triumph over Nature moves the multitude if the victory is such as to be vividly recognized. If it were necessary, numberless achievements could be cited, but consider only the com-

monplace act of riding in an automobile. A family group will ride with much pleasure for hours over highways which present no unusual scenery and at a speed at which fruitful observation is fairly difficult or even impossible. Of course, sunshine and fresh air are enjoyed, but these may be obtained to better advantage usually by walking. Sitting comfortably in the automobile, gliding over the highways, a great portion of the enjoyment experienced by the average person arises subconsciously from the satisfaction of *not walking,* or, in other words, of a triumph over Nature.

As we invoice the past we note many victories, great and small, but none which has touched mankind in general more deeply than will the one which now looms before us and is even enveloping us. As early as the eighteenth century flight by balloon had contributed many thrilling episodes and in earlier centuries the evolution of balloon flight is interwoven with the names of many philosophers. Late in the nineteenth century some progress had been made toward the use of motive power which would emancipate the balloon from the tyranny of air-currents. But the mastery of the air is in reality an achievement of the twentieth century. The heavier-than-air craft adopted from the automobile the motive power which has been such a large factor in mankind's most recent major triumph. During the early years of this century experiments were in progress which were to prove epoch-making; however, the desired

stimulus was lacking. In fact, there still resounded the persecuting ridicule which was heaped upon Langley during his classic work some time earlier. But the intellects of those persevering pioneers, directed by imagination which penetrated the unknown, laid the foundation of that knowledge which was destined to become "the wings wherewith we fly."

Mankind pays for progress in many kinds of sacrifice. The terrible competition of warfare stimulates effort and forces from the brain of man a flood of ideas and developments which under normal conditions would be spread over a half a century. This is no defense or excuse for war, but amid the wreckage of modern war there is much salvage. It is not a total loss. The World War bequeathed to the present generation a wonderful heritage—the mastery of the air. When it broke in all its fury it was at once recognized that the airplane injected the third dimension into reconnaissance and that it could be used effectively as an offensive weapon. Due to this irresistible impetus man thought and worked and took chances. Improvement followed improvement in rapid succession and the uncertain, hazardous plaything of dare-devils in 1914 emerged from the crucible at the cessation of hostilities four years later, a staunch, dependable, highly developed machine adapted to many uses for all mankind.

The airplane now holds open the doorways of a wonderland to mankind. Will he enter with see-

ing eyes and open consciousness? It has brought the arctic regions of the upper levels within an hour or so of earthly beings. Man may visit the fairyland of the clouds in a half hour after dinner and enjoy the splendor of sunset tints in this marvelous gallery of vaporous sculptures. It awaits to take him to those heights from which incomparable panoramas unfold and melt into distant air, a hundred or two hundred miles away. For the individual who aims to enjoy the fullness of living it has brought two great blessings—it has shortened distance and it has lengthened time. A tedious journey is shortened by the speed and directness of air-travel and, although the hands of the clock may describe a lesser angle, this time-interval is greatly lengthened for the conscious and knowing aerial traveler by the intensity of experience which is crowded into it.

Thus we have passed the verge of one of the greatest triumphs over Nature—one of the greatest strides along the highway of progress. Is there a person who is not stirred to thankfulness for the privilege of witnessing this advent of mankind into the aerial realm? In fact, the mastery of the air is an achievement which perhaps will never be equaled again when considered from the viewpoint of the vast variety of experiences it may bring to mankind. Flying is already a commonplace experience for many thousands of persons. This generation will see the addition of millions to the ranks of those who have invaded this hitherto

sacred realm; who have drunk deep of its thrills; who have seen its magnificent and awesome sights; and who have played hide-and-seek with the imaginary fairies of cloudland.

There may be some who would question the statement that man now is master of the air, but mastery like many other terms is a relative one. Mastery of the air is complete for those who have ascended in an airplane at hundreds of feet per minute to, through, and above the lower and intermediate clouds until more than half the earth's atmosphere lay below them; who on a clear day have seen the horizon of the earth two hundred miles away in all directions; who have become intimate with the mechanisms of storms; who have dodged the wrath of these magnificent phenomena by passing over or around them in the peaceful atmosphere and blue-canopied skies of the remaining vast panorama; who have remained in the air continuously an entire day supported by motive power under their control; who have made trips in a few hours that would have been next to impossible in an equal number of years by earth-travel; who have climbed into the solitude of space to such heights that most of the earth's haze, and consequently most of the brightness of the sky, were below them; who have looked into this almost black sky with the piercing sun boring through, untempered by the void of interstellar space; who have looked down upon an indistinct earth blurred by sunlit haze and distance; who have experienced

the arctic cold of these frigid altitudes; who, through the sheer enthusiasm of the conqueror, have dived and spinned and looped downward through those intervening miles between this world of space and our earthen world to emerge from the clouds and haze to a safe landing. These persons cannot but feel that they are lords of the aerial kingdom and reign unchallenged except by the limitations of earthly materials. Of course, the height to which aircraft may ascend will always depend upon the presence of a sufficient amount of air, but there are limitations also to other modes of travel. In fact, all our past conquests have their limitations. We daily trust our lives to the strength of steel in railway transportation; we ride at high speed in the automobile trusting to tires, axles, and steering gear; and we sail the seas with many risks overshadowing. But in these more commonplace activities we feel that we are masters.

Those whose vocations train them to be observant are universally impressed and depressed by the fact that man is not generally a close or at least not a conscious observer. Along the highways and byways of life there is much of interest for the imaginative observer who sees when he looks, but unfortunately few persons see the wonders and beauties on all sides and still fewer are inspired by them. Settings full of wonders and beauty, and situations charged with interest are drab and dull to most persons. We extract from

a painting or from a sunset, or even from life itself, in proportion to what we put into it. These are merely instruments to play upon; to draw from us something which after being embellished and multiplied is returned to us. And throughout all these experiences the possession of knowledge adds interest to the things which are seen and felt.

The air is a new realm except to the few scientific men. Its laws, its whims, its pitfalls should be known by the aerial traveler. Pleasure and even safety will depend often upon reading the signs judiciously. Many of the facts of the aerial world are invisible to the eyes because the fluids of the atmosphere are transparent. The winds would go their whimsical way unseen except for their effects upon clouds. They are the ringmasters of the clouds and are made visible by the structures, directions, and velocities of these visible vaporous bodies. The clouds thus become the signposts along the highways of air-currents, their ever-changing forms telling the hidden secrets of the winds and even foretelling the aerial conditions which are to come to-morrow. The haze, the sunset-colors, and the many meteorological facts of altitude, season, and locality combine with the changing scenery of cloudland and the variety of the landscape to provide the observer who sees with more than he needs to occupy him fully; with more emotions and sentiments than his psychological being may accommodate; with more inspirations than his imagination and finer sensibili-

ties may utilize during his hours in the air. But in order to experience the fullness of this kingdom he must open his eyes and his consciousness.

Opening the doorway of his intellect to the wonders of the sky and of air-travel has another far-reaching practical value. Although flying already may be considered quite safe, the possibilities of accidents are more terrible to contemplate than those attending activities which are not as novel. A busy mind has less time for contemplation when drinking from the perpetual spring of delights, thrills, and inspirations. Mental idleness magnifies danger, and time for contemplation undermines the nerves. These could be called to account for robbing many of the full enjoyment of flying and even for wrecked careers and fatalities. Many thousands and perhaps millions of the present generation to whom flying is still a dreamed-of thrill will, in the next score of years, come to view air-travel as a commonplace event. It will be unfortunate if these thousands enter the domain of three-dimensional traffic with unseeing eyes and with unresponsive imagination.

It is one of the aims of this little volume to aid in lifting the veil so that flying, after the initial novelty has vanished, does not become merely a period for contemplating the earth's distance and hardness or merely an interval of speeding through a spacious solitude of void. But how inadequate are words for describing the poetry of flying! The masterpiece of painting is only ade-

quately done in pigments, the media for that purpose. The author is conscious of the limitations confronting him but he hopes that the treatment from two viewpoints, namely, that of the earthly observer and that of the aerial traveler, will convince the reader, regardless of his personal interest in flying, that the sky is unexcelled as an interesting realm or aspect of nature. Its technical, artistic, and psychological interest is as boundless as itself. These chapters drawn from experience are attempts to interweave some of the wonders, the beauties, the thrills, the emotions, the inspirations, the technical facts, of the aerial kingdom in such a manner as to interest the general reader and to aid the aerial traveler to enjoy the wonderful heritage of the twentieth century.

CHAPTER II

THE COUNTENANCE OF NATURE

"To him who in the love of Nature holds
Communion with her visible forms, she speaks
A various language."

—BRYANT.

THE sky is the countenance of Nature upon which its endless variety of moods and emotions is displayed. A clear deep blue sky expresses the calm and serenity of content and peacefulness, but with the appearance of clouds Nature awakens and henceforth the heavens express various moods and emotions. When clouds are in the sky Nature may be idle, cheerful, happy, capricious, dull, sullen, angry, or terrible. The moods are often momentary, following each other rapidly and without order, yet at other times they modulate slowly from one to the other, and often their sequence may be predicted. Sometimes Nature's countenance may be serene and calm for days as though recuperating from excesses of the deep passion of a summer storm, or it may be sullen for weeks during midwinter. After a violent destructive blast of a summer storm, how often the sudden calm and clear sky suggest the youth-

FAIR-WEATHER CUMULUS CLOUDS

ful culprit who by a serene countenance pretends that he "didn't do it." As Ruskin says, the sky is "almost human in its passions, almost spiritual in its tenderness, almost Divine in its infinity." Surely no other aspect of Nature affords such whimsical, beautiful, and interesting variety as the sky and its clouds.

The earth's cloak varies from season to season, one aspect modulating slowly and imperceptibly into another, but the clouds, borne on the winds and modified by them into delicate, intricate, rugged, and majestic forms, will reward the conscious observer hourly and even momentarily for glancing skyward. Add to the beauty of these modellings, the color effects produced by sun, sky, haze, and shadow, and the heavens framed by any window become a succession of superb masterpieces defying the human genius of the masters who would paint them. Rich indeed is he who possesses the ability to see and to sense these heavenly scenes and whose imagination, that divine heritage bestowed upon every human being, has not been stifled by the ways of modern civilization. The sky with its expressive clouds is the one charming aspect of Nature which follows mankind from the open places to the congested cities. Even the cave-dweller in the metropolis is not denied the beauties of cloudland except by himself. He needs only to lift his eyes and open the doorway to his consciousness.

A painting, an interior, or one of Nature's nooks

may merely reflect the mood of an individual if that mood is definite and powerful but even such objects and limited environments exert their influence upon the mind. Those possessing finer or more responsive sensibilities usually respond to the mood of their surroundings. But in nearly all cases the extensive sky is master. How often does the individual take his mood from the sky at his first morning view from the window. Who may not respond to the cheerfulness of a fair-weather sky with its peacefully drifting clouds, regardless of the intensity of his mood or passion, if he will give Nature a fair chance? Who is not susceptible to the serenity or languor of the clear unbroken blue canopy of a calm day? And who has not been depressed by the gloom of the leaden sky of a rainy spell? Under great joy or sorrow Nature may be temporarily defeated but usually the sky with its variety of moods is overwhelming by its infinity. It is not approached in this respect except perhaps by the sea. Even an expanse of water bounded by the horizon owes its psychological influence largely to the expression of the canopy above it which is more extensive and more generally expressive.

It is strange how unacquainted most persons are with the heavens. Nature has done much in this part of creation which may interest, please, and instruct mankind; still the sky is almost ignored by the multitude. The veneer of modern

civilization has reduced man's sensibility to the calls of Nature. Modern educational systems do little or nothing toward developing or even maintaining the divine gift of imagination to each child who begins a sojourn in this world. They do not teach the art of observation or the philosophy of life or of living. They ignore a fundamental fact that man extracts from his journey according to his ability to extract. If Nature would send a storm-cloud occasionally across the sky to water the earth the purely utilitarian purpose of the sky would be satisfactorily fulfilled. One must conclude when in a fanciful mood, that the beauties and passions of the sky are to please and to interest man.

Nature is bountiful; she usually gives heaping measure. For example, the wonderful gift of color-vision which enables man to see a magical drapery over all creation is merely good measure, for a color-blind mankind could exist without inconvenience and be happy. The sky by its position is surely meant for all, but how many see its marvels, learn its lessons, or give it thought? How many to-night are able to recall that rugged range of vaporous mountains which floated above the southern horizon nearly the whole afternoon? Do those who saw it remember the delicate pastel tints of its rocklike crests emerging from the deep purple depths of the sea of haze? Bayard Taylor would have seen them—

"Bathed in the tenderest purple of distance,
Tinted and shadowed by pencils of air,
The battlements hang o'er the slopes and the forests,
Seats of the gods in limitless ether,
Looming sublimely aloft and afar."

Of the millions of persons who on any autumn evening looked toward the sunset (because it lay in the direction in which they looked), how many consciously saw the vari-colored display with its deep shades of color peculiar to the season?

If they did see the sunset did they feel the mood of the scene? Did the rose-fringed purple-shadowed clouds floating slowly, tranquil in spirit, inoculate them with the same restfulness so delightful after the day's work is done? Did they,—but never mind, for there is no end.

Those millions who daily ignore the wonders of cloudland will be awakened, to some extent at least, to an appreciation of this fairyland when they visit it in the winged craft which can take them on such a sojourn and return them safely in a brief hour at the end of the day's work. The automobile is still a marvelous recreative agency, for by means of it those imprisoned in congested cities may reach the open, clean, and quiet places in a short time. It has brought the freedom of the country almost to the door of the city apartment, but compare this blessing with the marvelous, almost dreamlike possibilities of the airplane. It will soon be just as easy to visit the fairylands in the sky after dinner on a summer's

day as it is now to visit the country by automobile. It is now just as possible. In a brief space of an hour or so in a powerful aircraft one may enjoy relief from the sweltering humidity of midsummer in the polar climate three or four miles above. Freezing temperatures will be found in summer nearly always at altitudes under three miles in the temperate zone.

Will the average person with his scanty or smouldering imagination appreciate the wonders of flying? Will he grasp the opportunities afforded by modern aircraft? Without imagination, the clouds will be accepted with indifference when among them. To those who see only with their eyes, the clouds of the distant sunset will always be indistinct and insignificant, but to the imagination, which reverses the perspective of the senses, these delicately tinted, pulsating objects will be alive, imposing, kindred spirits, however distant. The sky may be appreciated by anyone, but is best described by the poet. The beauty of the paintings of the sky by the masters is one of the most forceful proofs of the beauty and expressiveness of the sky. These efforts of the greatest masters are at best only weak, dull, and lightless ghosts of the originals but even they are charming, beautiful, and expressive. What, then, of the originals!

In the following lines Coleridge notes the pleasure of using clouds as vehicles for the imagination,—

"O, it is pleasant with a heart at ease,
Just after sunset, or by moonlight skies,
To make the shining clouds be what you please,
Or let the easily persuaded eyes
Own each quaint likeness issuing from the mould
Of a friend's fancy."

In literature are described many of the impressions which the sky and its inhabitants have made upon delicate and attuned human sensibilities. The sun, moon, stars, clouds, storms, sunrise, sunset, blue sky, halo, corona, and aurora have all been subjects of poets of verse and of prose. The many allusions by poets to the sky and to its inhabitants lead one to conclude that the sky is as important to poets as to painters. Even in poetry and painting, some knowledge of the facts of the clouds is useful, and both have displayed the results of study. Ruskin's discussions of clouds in painting would be greatly condensed, more readable, and more instructive if he had taken the pains to become acquainted with the facts available at that time. Doubtless, the poetry and painting of the future will show the effects of more accurate knowledge and closer acquaintance with the clouds gained by the intimacies possible through flying. The influence of aviation is even already slightly felt in such circles, but its greatest effect is doubtless still somewhat in the future, although perhaps not far off.

The forms of clouds, their groupings, their altitudes, their velocities, their relations to each other

and to the topography of the earth's surface, all these phases and others cannot be fully visualized or appreciated without touring through cloudland. Views from the earth are always deceptive, being complicated by the effects of perspective and the one-sided view. Obviously, the form of a cloud will be easily and fully appreciated after it is viewed from various sides,—below, on its own level, and above. The aerial traveler is often surprised and even astonished in his early experiences in cloudland by some of the false conceptions he has formed especially regarding cloud-forms. He soon notes that clouds may be divided into general classes and that altitude gives certain characteristics to them. In general, he concludes that clouds become thinner, less massive, more tenuous with altitude just as the density of the atmosphere diminishes with height. He may note that in so far as form is concerned, clouds may be divided into three regions according to altitude, namely, low, intermediate, and high. Knowing that clouds owe their forms to air-currents—winds, eddies, vertical convection, etc.—he may generalize regarding the relations of these with altitude. But it is well at first to go no further with generalizations because of the complexity of the aerial kingdom.

It is convenient and not without logic to consider the three cloud regions mentioned above, and some general characteristics will be noted. In other chapters more details are presented.

Several general forms exist in these three regions and, of course, the actual individual forms are infinite in variety. It is this ever-changing form that is so fascinating, but despite this variety, the task of classifying cloud-forms is not hopeless.

The high clouds, the cirrus and its combination forms are usually out of reach of the aerial traveler and at the present time some of them have not been reached by the highest flights recorded. These cirrus clouds are sometimes at such altitudes that they would float far above the highest mountain in the world. They are in the region of speeding winds which whip them into streamers and a vast variety of wind-driven shapes. They are often characterized by symmetry of ripples, billows, and curls. They float in the frigid, clean atmosphere and always consist of ice crystals. Sometimes they are so vanishingly thin that they are barely called into existence by the powerful untempered sun which illuminates them. In this clean rarefied atmosphere the blue skylight creeps into their delicate shadows. These tenuous clouds, sometimes vanishingly thin and always wind-swept into ever-changing patterns, are perhaps the most fascinating of the general types of clouds. They are subjects for poets and painters. They are the last bright clouds in the sky after the sun sets, and long after the sun has disappeared from earthly view these wispy veils are immersed in the golden glow of the sun which is just setting for them. Such a sky viewed from the deepening

shadows of twilight on earth is one of the impressive moments in the kaleidoscope of the heavens, for it is a "majestical roof fretted with golden fire."

The beauties of these upper clouds do not depend upon the colors of sunset although they are greatly enriched by them. Their delicate, changing forms awaken fancies and taunt the master who would paint them. Here the fairies find their filmy veils, delicate lace, the richest embroidery, and combinations of these, well becoming them. The halos around the sun and moon are the handiwork of these high thin veils.

The clouds of the middle region would likely be characterized by the aerial traveler first, as sociable, clannish, or flocking. Cloud-flocks are indeed found at other altitudes but they are more predominant among the forms of the intermediate clouds than in other regions. They are generally thicker or more massive than the tenuous upper clouds and, therefore, display a variety of light and shade uncommon in the thinner clouds of the high region. However, the forms of the individual components vary from the thin delicate flakes separated by patches of blue to the fleecy globular masses closely packed. These afford the painter, poet and nature lover, relief from the monotony of the blue. In this middle region there are plenty of other types of clouds including the less varied stratus type which gives rise to coronæ around the sun and moon, but the groups

doubtless will more effectively stir the fancies of the observer and interest the student of clouds.

The "mackerel" and "billowed" skies of this region are perhaps the only types of clouds besides the cumulus clouds of summer that hold the attention of the casual observer sufficiently to enable him to describe them from memory. The symmetry of the flakes or globular masses in lines in one or two directions is too striking to go unobserved. Many fanciful interpretations are possible. The clouds in this region are often seen to evaporate or to grow denser momentarily. This adds to the great variety of the cloud-effects and cloud-forms of the middle region. These flocks or billowed oceans of clouds are among the superb sights in air-travel. On rising to the level of one of these billowy seas of clouds, one may note the minute details of air-currents made visible. Here one sees and feels the full glory of the kingdom of cloudland as he enters the ballroom of the fairies. And to think that mankind can now enter this fairyland and return during the recreation hours of the day! The wings of imagination have given way to the wings of reality.

The clouds of the low region which are likely to attract the average person are the heaped or cumulus clouds. These appear to rest on flat shadowed bases and to rear themselves in turbulent crests. Fancy makes of these, rocky crags, huge promontories, rugged peaks and ranges.

They are perhaps the only clouds generally observed. Overhead they appear as fleecy masses, grayed by shadow, not very interesting in pattern but serving to break the monotony of the blue. The fair-weather type sail gently along over the tranquil blue sea of space tinging a lazy mood with some signs of life. The more interesting and striking cumulus clouds are those seen nearer the horizon. At this oblique angle much of the beautiful detail of their turbulent crests is visible. Their flat bases rest in the blue haze of distance and the thunderhead rears itself upward sometimes above the middle region—as high as the highest mountain. Those underneath see a darkening, threatening, frowning cloud advancing with its deluge.

After such a cloud-mountain or cyclonic storm has borne down and has spent its energy, the scenery or properties are left to be cleared away by the winds. This chaos of cloudland affords both the earthly and aerial observer many splendid views of various types of clouds and their rapid evolution into different forms. The fogs, the delicate phantom-like scuds, the darkening cumulus clouds *en échelon*, the leaden skies, all contribute interest and variety and indicate Nature's moods to follow. The tall mountain peak in the distance is favored with a sunshade of cloud. At other times this becomes a vaporous cap or mantle. Sometimes a white banner appears to wave from the leeward side of the crest.

All these kindle the imagination; each one is of interest and worthy of attention and thought, for it has a cause behind its existence. These are the details that color the monochrome of life of the unseeing into a masterpiece of glorious splendor and untiring variety for the observant whose sensibilities are attuned to respond to Nature's advances.

The sky provides all the moods of Nature which the painter strives to portray and more. The painter's efforts are commendable and enjoyable but he can never do justice to the sky and its moods. He has merely earthly pigments, weak imitations of light, which do not have the strength or range necessary to record the heavens. A painter finds it difficult to represent a horizon blending from the mists into twilight or a mountain melting into its shroud of cloud. How can he then hope to represent the white crests of clouds illuminated with untempered sunlight simultaneously with the shadows of his mountains or forests in his landscape? In a similar manner the poet's media are weak and lacking in range and expressiveness, still his descriptions are beautiful. Notwithstanding the painter's handicap of earthly pigments which at best can only feebly represent clouds, his canvases are interesting, charming, and beautiful. This testifies to the overwhelming superiority of the originals. Then why not observe and enjoy them and learn their meanings?

CHAPTER III

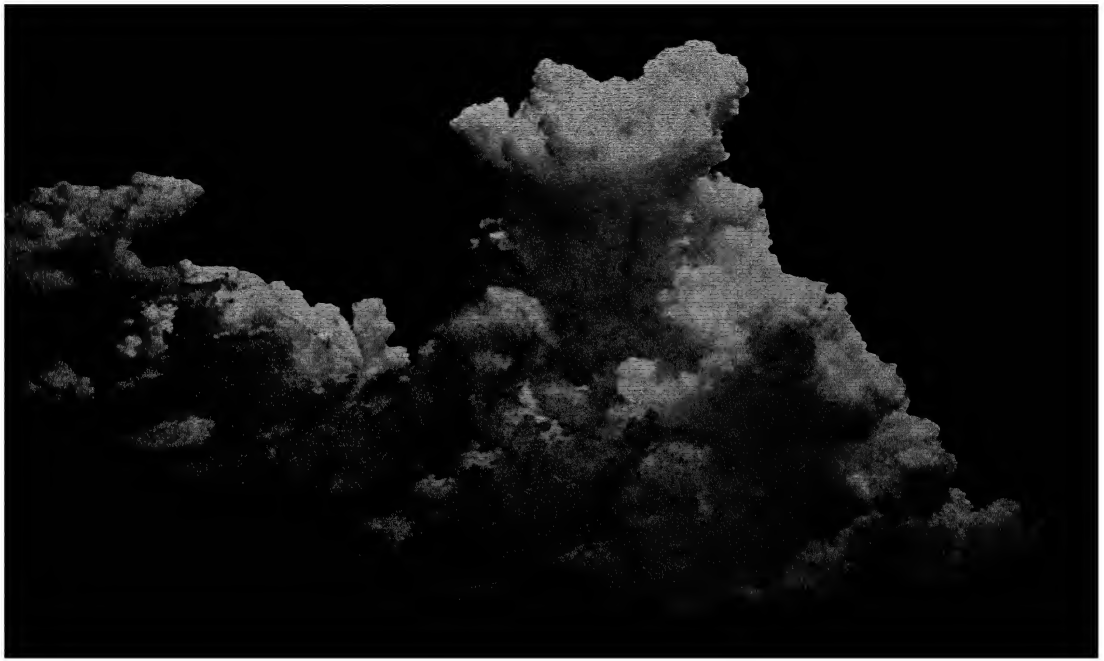
THE FORMATION OF CLOUDS

"Aerial spirits by great Jove design'd."
—HESIOD.

THE multitudinous forms and varied colors of the clouds not only provide landscapes and seascapes with an ever-shifting scenery to please the eye and to hold its interest, but they teach lessons of winds and weather. Some knowledge of the source, structure, heights and meaning of clouds provides another phase of interest for earthly observers, aerial travelers, and various students of the heavens. Clouds are the visual manifestations of air-currents, for they are modeled and driven by these currents. They tell much regarding meteorological conditions, direction of winds, and to-morrow's weather. To the cloud-wise they reveal something of the temperature and humidity of various regions of the atmosphere. Knowing their source and their relations to other conditions, such as barometric pressure, it is possible to foretell the kind of weather which is likely to be near at hand. Every phase of the weather is commented upon by clouds ex-

cepting, of course, clear weather. They play visible parts in the entire pageant of storm from the heralds and banner-carriers of the procession to the straggling rear-guard and those who have lost their way.

Clouds are formed in clear transparent air by the condensation of the invisible water-vapor which generally exists in the lower atmosphere. Water-vapor is gaseous water and is as invisible and transparent as the air itself. A cloud of condensed water-vapor consists of minute globules of water. These individual droplets may be said to be transparent, nevertheless they scatter light by reflection just as clear polished glass beads and marbles are seen to do. In such glass spheres the reflection of objects may be seen which indicates mirror surfaces and therefore the ability to scatter light by reflection. Another illustration is that of sandblasted clear glass such as a lamp bulb. If this surface be viewed under a micro scope it will be seen to consist of a vast number of smooth surfaces oriented in a haphazard manner just as they happened to be chipped by the sandblast. This magnified roughened glass appears similar to ordinary "chipped" glass. If a sheet of clear glass be finely pulverized the powder is as white as snow and still each minute particle is a clear transparent fragment. All polished surfaces reflect light whether they are transparent or not and, therefore, these many transparent particles of powdered glass or droplets of



A MAJESTIC SCULPTURE OF CLOUDLAND—A CUMULO-NIMBUS SEVERAL MILES IN HEIGHT

water-vapor by reflecting light in all directions give the body a translucent and luminous appearance.

Air is able to hold a certain percentage of water-vapor but its capacity depends upon its temperature. For example, warm air is able to retain a greater percentage of water-vapor or moisture than cooler air. The absolute humidity is the mass of water-vapor contained in a unit volume of air. When a certain volume of air contains all the moisture which it is able to retain at that temperature and pressure it is said to be saturated. The relative humidity is the ratio of the actual quantity of water-vapor in a certain volume of air to the total quantity which would be present if the air were saturated, other conditions remaining the same. The dew-point is the condition when complete saturation is reached, temperature and pressure remaining unchanged. The "sweating" of water-pipes, the formation of frost, and the deposition of dew show that atmospheric moisture promptly condenses upon any surface whose temperature is below the dew-point. That is, the cooling lowers the capacity of the air for water-vapor so that some of it must condense. In a similar manner, volume condensation takes place throughout a body of moisture-laden air when it is sufficiently cooled. This cooling can take place by expansion of air when the pressure is reduced such as in an ascending current of the atmosphere, by contact with colder surfaces, or

by mixture with colder air-currents. The result of this condensation is fog or clouds of innumerable droplets of water or ice particles. Nuclei, such as dust, smoke particles, and electrons seem to be necessary for the condensation of water-vapor.

The form and altitude of clouds depend somewhat upon their mode of formation, that is, upon the manner in which cooling takes place. Fog differs from cloud only in its location. It is formed by relatively low temperatures near or at the surface of the earth. Clouds are generally produced originally by the cooling of the air by convection currents. These currents are upward, hence, clouds are separated from the earth by a considerable altitude. The final forms of clouds are very much modified after their initial formation by the modeling and even disruptive action of air-currents. When the temperature of the air is below freezing the condensed moisture is in the form of ice crystals but some water-vapor is also present. If such air were carried to higher altitudes and mixed with colder air, or cooled further by expansion, some of this remaining water-vapor would condense into ice crystals and thus become visible. These are the important factors in cloud formation, but the details which are definitely known would fill many large volumes. It is not the intention here to give more details than necessary to enable the reader to appreciate the interesting, useful, and pleasing functions of clouds.

Clouds do not come from a mysterious source and disappear into another unknown. There is logic and reason behind them. Sometimes they are born hundreds of miles distant in any of the variety of shapes from the towering cumulus to the thin fibrous cirrus. They may be carried on by the winds, buffeted by cross-currents, modified by temperature conditions, altered by the topography of the earth, disrupted by battling winds and upward currents, finally to evaporate or to spill rain or to float onward after delighting those who lift their eyes to the wonders of the sky.

Clouds often form before the observer's eyes by the condensation of the moisture in the heavily laden air. For example, the cumulus cloud—the product of upward currents induced by the warm earth and lower atmosphere—consists of vapor condensed by expansion or by the colder upper air as it is carried upward. The altitude of the crests of these clouds varies somewhat depending upon the velocities of the individual convection currents. The flat darker bases of the cumulus clouds indicate the altitude above which the conditions of humidity, pressure, and temperature are satisfactory for the condensation to take place and below which the capacity of the air for holding water-vapor is not wholly filled. This flat base represents the altitude where the dew-point is reached as the temperature and pressure changes.

Clouds float in the sky because the individual droplets are so minute that the viscosity of the

air is very effective in retarding their fall. They actually would gradually settle in still air, and in general there is always this component intermingled with the effects of air-currents. It is not surprising that these minute drops of water float, if one considers other examples. Dust will float in the air for some time before reaching the earth's surface by settling. However, a clod of dirt will fall immediately.

In order to recognize clouds and to discuss their details of formation, structure, and meaning, names must be given at least to general classes. They vary in altitude and assume an infinite variety of forms so that it is difficult to choose a simple terminology which adequately meets the requirements. Those who have flown among the clouds and have observed their altitudes and forms from all sides should have little trouble in recognizing the various types of clouds from the descriptions which follow. In viewing clouds, the distortion due to perspective should be appreciated and accounted for. For example, the flat dark bases of the cumulus clouds as seen from below make a group of these appear *en échelon*. The confusion due to perspective is much greater from viewpoints on the earth than in the clouds.

A condensed form of classification of clouds according to altitude and form appears to be satisfactory for the purpose of this book. For convenient reference clouds may be divided into four

primary and nine secondary forms. These are as follows:

Primary forms

- Cirrus, or curl cloud
- Stratus, or layer cloud
- Cumulus, or wool-pack cloud
- Nimbus, or rain cloud

Combination forms

- Cirro-stratus
- Cirro-cumulus
- Strato-cumulus
- Cumulo-nimbus

Alto forms

- Alto-stratus
- Alto-cumulus

Fracto forms

- Fracto-stratus
- Fracto-cumulus
- Fracto-nimbus

Several combinations of names are omitted as will be seen on closer study. For example, cirro-nimbus is omitted because rain clouds never have the cirrus form; there is no strato-nimbus because all rain clouds are flat; fracto-cirrus does not appear because cirrus clouds are always fibrous, broken, and detached; there is no alto-nimbus because rain clouds are never high.

According to altitude clouds may be divided conveniently for many purposes and especially for the aerial traveler. In the classification which follows, those preceded by *d* are seen most frequently in dry weather and are generally separate or globular, or made up of flocks of individuals. Those preceded by *w* are "wet weather" clouds and are widely extended in form often covering the sky. Altitudes are presented more in detail in later paragraphs.

Upper clouds, average altitude 30,000 feet.

d. Cirrus
w. Cirro-stratus

Intermediate clouds, between 10,000 and 25,000 feet.

d. Cirro-cumulus
Alto-cumulus
w. Alto-stratus

Lower clouds, under 10,000 feet.

d. Strato-cumulus
d. Cumulus
w. Nimbus
w. Fracto-nimbus
w. Stratus
w. Fracto-stratus

The cumulus, fracto-cumulus, and cumulo-nimbus, all of which are caused by diurnal convection, vary in altitudes from a few thousand feet to 25,000 feet so that they are sometimes

lower and sometimes intermediate clouds. The "dry weather" cumulus is usually a lower cloud with its apex at about 6000 feet and its base at about 4500 feet. The cumulo-nimbus or thunder-storm cloud rears its apex to altitudes from 10,000 to 25,000 feet, its base being at about 4500 feet.

These are some of the general facts of clouds and may be sufficient for some readers; however, more details are found in other chapters.

CHAPTER IV

THE THUNDERSTORM

"I wield the flail of the lashing hail,
And whiten the green plains under,
And then again I dissolve it with rain,
And laugh as I pass in thunder."
—SHELLEY.

A MIDSUMMER morning opened dazzlingly bright and very still. The bluish-white sky was bright with the haze of the hot, sultry days of the thunderstorm period but not a cloud appeared against this background. There was "green calm" below and "blue quietness" above. It promised to be a dull day for flying for those who yearn for the fairyland of the clouds, but two lords of the air ascend for a trip into their aerial kingdom. The earth below is of interest in its variety of dull colors which become duller or grayer as they ascend, leaving more and more of the sunlit haze beneath them, but this expanding landscape does not compare with the beauties and wonders of cloudland. In the distance the horizon is invisible, the earth is gradually blending into the sky as it is blotted out by the increasing depth

ONE OF THE AWESOME SPECTACLES OF THE AERIAL WORLD—
A THUNDERSTORM VIEWED FROM THE HEIGHTS

of haze which is encountered in oblique vision. No earth horizon is visible owing to the accumulation of smoke and dust-haze carried upward by the convection currents induced by the hot earth below. Then at an altitude of about one mile a horizon appears; it is that of the floating haze and this altitude marks the upper limit of the upward diurnal convection air-currents in this case. An unbroken haze horizon presents itself on all sides as though a surrounding sea had been lifted vertically one mile.

In the distance a few cumulus clou. sleepily rear their cauliflower heads out of the haze like nearly submerged icebergs. In the oblique sunlight the colors of the haze are delicate pastel tints of blue, pink, and purple, but the crowns of the distant clouds are brilliantly yellow-white against the deep blue sky. No upper clouds are present, so the azure canopy is unbroken. The aerial travelers turn instinctively toward these clouds which are poking their heads above the smudge of the earth haze which surrounds their bodies, and steer a course toward one which is energetically rearing itself higher and higher. They are thirty miles away but the aircraft annihilates distance at one hundred miles per hour. Rapidly the clouds draw near and soon the terrific roar of the aircraft reverberates among these vaporous crags. Upward the craft climbs toward the summit of the thunderhead. Eight, nine, and ten thousand feet are successively indicated by

the altimeter and at twelve thousand feet the crown is reached. The flyers pass over it and back through it and wander down the sides in a succession of antics in the exuberance of freedom. Anything to pass the time, for they intend to watch the evolution of a thunderstorm.

At noon they again find themselves on the cauliflower crest which has by this time reared itself seventeen thousand feet above the earth's surface. Here it stands majestically supreme, a mighty crag of vaporous cloud surrounded by isolated miniatures two miles below. It is time for lunch and the fuel is low so the airmen start for their landing field at an easy glide. Minutes pass and the altimeter clips off the thousands of feet. At seven thousand feet the level of the smaller clouds is reached and they look back upon the majestic thunderhead rising two miles above his assembling cohorts. Downward they continue their course and onward to their lunch thirty miles away. On landing, nothing is seen of this group of clouds in the distance except the crest of the thunderhead, a delicate pinkish pastel tint almost submerged by the bluish haze. The lesser depth of haze between its looming crest and the observers does not quite obscure it, but its body and base and the large group of lower minor cumulus clouds near it are in obscurity behind the depths of miles of a midsummer veil of haze. The aerial explorers are not in haste despite their desire to see the evolution of a thunderstorm be-

cause they know that on this still day the clouds will not travel out of range of their speedy craft and that thunderstorms are most prevalent in the afternoon. They are also fairly certain that this thunderhead will continue its evolution into a thunderstorm because the hot day, the high humidity, and quiescent atmosphere are conducive to this end.

Lunch is over, fuel is supplied to the aircraft, and minor details are looked after but the airmen need not hasten. They find a shady spot and chat, casting occasional glances over the pastel-tinted sky unbroken except in one place near the horizon where their thunderhead is gently floating showing its crest faintly through the deep bluish haze. Sometime later the lower sky in this direction has darkened considerably and the explorers don their warm clothing in the sweltering heat, for they are going where the temperature will be near zero. They ascend and in a short time are above the haze. What a change has taken place in their thunderhead! What a titanic army of clouds has come to reinforce that majestic leader! The aircraft steadily climbs as it approaches this mass of cloud mountain. At the lower altitudes the real form of this cloudscape cannot be distinguished. Perspective is deceiving and none of the upper surface can be seen. Higher and higher they mount until at ten thousand feet they are above the level of the minor supporting clouds. Fifteen thousand feet is reached and they approach the

level of the main body of this turbulent mountain. Still the crest of the thunderhead looms thousands of feet upward. At twenty thousand feet they are above the level of all except the central crest which extends several thousand feet higher.

What an awesome sight this boiling mass of clouds is to the two human pigmies in their insignificant craft! The mighty thunderhead has been stretched skyward by the powerful upward currents from the hot earth below until from its flat dark base a few thousand feet above the earth to its brilliant cauliflower crest, four vertical miles intervene. Reinforcements of lesser majesty but compensated for in number are packed closely around the mighty center and are stirring impatiently. In this manner the huge restless mountain of clouds, whose nucleus is the thunderhead, is built up, recalling to the imagination the solid phalanx of the Greeks surrounding their powerful leader.

The cloud-mountain, as large as any earthly mountain, is a befitting abode of Jove when he is in a mood for work. Flash! A lance of blue-white light starts from somewhere in the crest and loses itself in a twinkling in the obscurity of the turbulent mass. Jove is at work hurling his thunderbolts. Could the airmen but stop the roar of their engine in order to hear the thundering accompaniment of the storm, the awesome spectacle would be complete.

It is bitter cold at this altitude and as the vapor

of the clouds condenses around the dust or electronic nuclei in the atmosphere, the raindrops thus formed at the lower altitudes are caught in the upward surge of the convection currents and are hurled vertically into this cold region. Thus tiny hailstones are born. They fall again outside the boiling center and gather more water only to be caught again at lower altitudes and hurled upward where another layer of ice and snow is added to them. This cycle may be repeated many times before the hailstones fall outside the influence of the storm center to drop to earth and spread destruction to crops and skylights.

A thunderstorm is characterized by thunder and lightning but the latter has no influence on its genesis, development, course, or destination. It is merely incident to, or a product of this type of storm. It may satisfy when in a fanciful mood to attribute the source of thunderbolts to Jove, but in reality the source of lightning is still shrouded somewhat in mystery. It is known that lightning is born in the storm but scientists have not explained the mechanism in detail. A strong upward current of air is a conspicuous feature of the thunderstorm. This is apparent to the aerial observers in the turbulent heads of the cumulus cloud which was the parent of the thunderstorm. This updraft carries raindrops upward if its velocity is greater than about eighteen miles per hour because raindrops cannot fall in still air with a greater velocity. This upward rush is

strong in this case as is evident by the high altitude of the crest of the storm clouds. Hail is produced by the freezing of the raindrops owing to the frigid temperature which the airmen experience at their high altitude. Air is drifting downward in some places because it cannot be rushing upward everywhere. The raindrops which have not been solidified may be torn to pieces by falling and by the upward rush of air. Electric charges are produced by tearing things apart and in this ceaseless turmoil in the thunderstorm the many raindrops torn asunder repeatedly may be the source of the electricity which manifests itself in lightning discharges. This mechanism is hidden from the aerial explorers as well as from the meteorologists on earth, but the airmen see the flashes of lightning repeatedly.

All this time they are nosing about the thunderstorm at a safe distance in the quiet atmosphere. They approach with the most intense feeling of awe yet encountered in their aerial travel, for there is one of Nature's greatest phenomena of concentrated energy. This mountain of agitated clouds, ever-changing in minor details but maintaining its general form, is watering the parched earth but also intermingling with this good-will the destructive effects of the hailstones and of those bolts of lightning which pass from cloud to earth. Many of the bolts pass from cloud to cloud dissipating their energy in a harmless manner, nevertheless frightening the more timorous of

earth-beings who look upward at the slightly undulating dark base of this vaporous cloud-mountain passing overhead. Little consolation do earth-beings find in the fact that lightning picks only three victims yearly out of each million of inhabitants in this country. Those underneath do not realize the majestic form of this thundering cloud which to them is frowning darkly. To them it may even be raining and thundering all over the world. Little do they realize that two human beings in a frail craft are four miles above them in the clear sunshine watching the mechanism of the storm from behind the scenes!

Those relatively few persons beneath the storm who are cloud-wise are not surprised by the thunderstorm's visit because the humid air and calm hot day warned them of such a possibility. For several hours before the storm came they had been conscious of low-lying cumulus clouds hovering along the horizon. Finally they noticed some of these rocky crests appeared to be rearing higher, partially owing to the illusion due to their approach. The earthly observers did not hear the thunder until the storm drew within fifteen miles but they knew by the dark base that a thunderstorm was moving upon them. When a strip of bluish white cloud resembling a wreath appeared in front of the approaching mass of clouds they knew that rain would be upon them in about ten minutes. As this squall-cloud approached it drew behind it a broad foreboding curtain of cloud

from some place below the horizon screening the majesty of the turbulent thunderheads from earthly view. By the unbroken grayness of this extensive sheet the cloud-wise persons knew that a heavy rain was in store. The gentle breeze which had been blowing from the south died down and calm reigned for several dramatic moments foretelling the imminence of the crash of the storm. Only the faint ominous roar of the approaching squall was heard. Finally, as it struck, the trees bent madly for a few minutes. Suddenly there was a crash of thunder and large drops of rain began to fall as though they had been jarred loose from the clouds above. The action then rapidly hastened to the tumultuous climax of the present moment for those far below the airmen. They are now in the midst of rain, hail, lightning, thunder, and wind.

The air men withdraw to a distance from the leading edge of the storm and peer downward toward the earth beneath the cloud-mountain. The earth is obscured under the falling rain and this view beneath gives them a glimpse of Nature's frown. The squall-cloud in front of the storm-center is rolling angrily in the shadow of the towering clouds. They know that preceding the approach of this squall-cloud a gentle breeze is fanning the earth. As the storm-front approaches, the wind shifts and becomes violent and gusty. The rolling squall-cloud is a manifestation of this wind in the cloud region, but when it has passed,

the wind becomes more gentle. They smile as they think of those beings far down on earth who see naught but this angry frown. In their imaginations they see those who are overtaken by the storm away from home or office huddled under a convenient shelter protected from the rain and trembling with each peal of thunder. They visualize the farmers putting their horses away, some of them berating the rainy day. The fall in the barometer would have told them of the approach of the thunderstorm. How delightfully cool the air is at the earth's surface, for it has just returned from the heights of the boiling crests in view of the airmen above.

All this time the aerial explorers are bathed in clear sunlight under a deep unbroken canopy of blue sky. Their attention during these exciting moments has been centered upon this awesome spectacle of turbulent clouds charged with rain, hail, and electricity. They have viewed it from all angles as close as they dared, for a sideslip into this mass would mean destruction to them. They turn from this huge mass of restless energy to the vast panorama surrounding them. The cloud-mountain which awed them with its power and majestic magnitude dwarfs considerably, for all about them is the vast panorama of clear sky and sunny weather. The storm, great as it is, is but a portion of the panorama. The cheerfulness of the sunlight and blue sky enters their beings. They note the brilliant white surfaces of the stormy

cloud-mountain and contrast this with the angry frown of the squall-cloud showing from beneath. Truly to them clouds have silver linings. Never again on earth will they succumb to the dark sullen mood of the storm. They smilingly note that Nature is sometimes two-faced, presenting a dark angry frown on one side and a bright silvery smile above.

The cold has crept beneath their polar clothing so they drop downward to warmer altitudes and investigate the quieter masses of clouds surrounding the storm-center. The huge cloud-mountain is already disintegrating and the fragments are dispersing to float away or to disappear according to the whims of air-currents. At eight thousand feet they reach the level of the overcast sky trailing for a distance behind the moving storm. They turn toward home with mingled emotions following this full experience with one of Nature's aerial wonders. They cannot escape an emotion of sheepishness, for have they not been spying upon Nature behind the scenes? Have they not seen that which hitherto has been obscured from earthly view by the dark clouds and rain? Surely mankind is triumphing over Nature.

They approach the field and glide to a landing removing their moisture-laden goggles, which owing to their coldness, condense the water-vapor in this hot region. They remove their high-altitude clothing, sticky with moisture as quickly as pos-

sible, for the heat is oppressive. As they hasten to a shady spot they are greeted with the remark of an earthly friend, "This certainly has been a hot day and scarcely a cloud in the sky all day long."

CHAPTER V

CLOUD-FORMS

"Sometimes we see a cloud that's dragonish;
A vapor sometime like a bear or lion,
A tower'd citadel, a pendant rock,
A forked mountain, or blue promontory
With trees upon 't, that nod unto the world,
And mock our eyes with air; thou hast seen these signs;
They are black vesper's pageants."

—SHAKESPERE.

THOSE who are appreciative of only the beauties, the witchery, the moods, and the passions of the clouds require no scientific terms for the endless variety of cloud-forms. Their imaginations respond with apt names very suitable to their fancy or mood at the moment. However, as the witchery of the clouds enslaves the attention of the observer more firmly, his kindled imagination is interrupted by more and more questions. The fanciful or esthetic mood must occasionally give way to an inquiring mood. The observer finds himself occasionally attempting to answer these questions. He begins to see logical relations

BILLOW CLOUDS REVEALING THE HUGE WAVES IN THE AERIAL OCEAN

between cloud-forms and to note their connection with winds and weather. Unconsciously he has become a student of the clouds. This will happen to many who begin by merely opening their consciousness to the wonders of cloudland, and this study will serve to increase their interest. There is little danger of scientific interest in the facts of clouds usurping the place of esthetic and fanciful interest and no thoughtful observer of the multitudinous formations and the variety of color can escape a longing for some facts and reasons. When he reaches this point he wants names for general forms, at least, to use so that his thoughts and observations may be orderly. The aerial traveler will readily learn to recognize the various types of clouds and will have much advantage over the observer at the earth in intimately examining their forms. To the aerial traveler the multitude of cloud-forms and their delicate details will come to mean more than beauty and prophecy. They will show him some of the intricacies of currents and eddies in the vast invisible sea of air. He will come to bestow upon clouds the additional attribute of making the unseen visible. Of course, there are many currents which remain invisible at all times because the conditions are not satisfactory for condensation of water-vapor. Science has supplied far more names than one requires for his everyday appreciation and study of clouds. In the following paragraphs will be found brief descriptions of the chief characteristics of the prin-

cipal cloud-forms and some special ones of interest.

Cirrus. These are the highest of all clouds, often at altitudes between 30,000 and 40,000 feet. They assume many forms from the thinnest haze to many detached forms. According to these forms, they may be described as delicate, fibrous, filmy, hairlike, tailed, ribboned, curled, ringleted, feathery, plumed. They are generally white in color but often appear of a yellowish tint in contrast with the blue sky. Sometimes they are arranged in belts, often like strands of hair or plumes of feathers, nearly always showing the effects of high winds, and by the effect of perspective, appearing to converge toward points of the horizon. They are frequently the result of cyclonic convections that sometimes extend as high as ten miles. When thus formed they are driven far in advance of the cyclone area and herald the approach of the storm-center or area of low barometric pressure. They are also common in the midst of areas of high barometric pressure, due perhaps to the lifting of the upper air or to the overrunning of the upper air in the general processes of air circulation. They are formed at low temperature often as low as 50° Fahr. which accounts for their tenuous character because little water-vapor could be present at these temperatures. The strife of the winds and convection currents is responsible for their many characteristic forms.

Cirro-stratus. The altitude of these clouds is slightly lower than that of cirrus, at an average elevation of about 26,000 feet. On the approach of the cyclonic storm the cirrus clouds thicken and gradually take the form of a thin white sheet or veil having the appearance of a tangled web and often covering the entire sky. Their origin is the same as that of the cirrus from which they evolve. They generally consist of ice crystals and are responsible for the halos around the sun and moon.

Cirro-cumulus. These are small globular or fleecy masses or white flakes of cumulus clouds generally at altitudes of 20,000 to 25,000 feet, that is, in the lower cirrus region. They possess very slight shadows and are often arranged in groups and lines. They occur in large numbers and may be described as "curdled" sky or "mackerel" sky. Their origin is usually due to local convection currents induced by unequal, local heating. For each convective rise of air there must be an equivalent descent, each rise being represented by a small cumulus surrounded by descending air and relatively clear sky.

Alto-stratus. This is a thick grayish or bluish veil or sheet with an average elevation of about 13,000 feet. Sometimes it is of a fibrous nature. It goes through the same changes in form as the cirro-stratus but its elevation is only about one-half as great. It gives rise to coronæ occasionally but not to halos. It may be formed in the air forced

upward by converging winds in the storm area of a cyclone, by the flow of warmer air over a colder layer, or by the cooling of the humid air due to the evaporation of alto-cumuli.

Alto-cumulus. These are rather large globular masses, white or grayish and partially shaded, often closely packed in groups or rows which resemble cirro-cumuli. The detached masses are usually larger and more compact at the center of the group. Those at the center are strato-cumuli. At the margin they form into finer flakes changing to cirro-cumulus. Their average altitude is about 13,000 feet, about the same as alto-stratus. They presumably owe their origin to local convection especially in calm summer weather when the relative humidity is low.

Strato-cumulus. These are large globular masses or large rolls of dark cloud more or less associated with thinner clouds which together frequently form a covering for the entire sky especially in winter. Occasionally the formation as a whole has a wavy appearance. The layer is not thick and often blue sky is seen through the intervening spaces. All the varied forms between this and the alto-cumulus are to be seen. It differs from nimbus by possessing a globular, rolling, or wavy structure and also because it is not a rain cloud. In fact, they generally appear in dry weather. Their bases are flat being generally at about the same elevation, from 5000 to 7000 feet. They are formed by vertical convection as is in-

dicated by their rounded tops and flat bases, the latter being at the saturation level.

Nimbus. This is the rain cloud and is a thick, extensive layer of flat cloud from which rain or snow is falling. The average altitude of its lower surface is about 3000 feet. It generally has ragged edges. Through openings in this low layer, an upper layer of cirro-stratus or alto-stratus may often be seen. It may be produced by the converging in front of cyclonic centers, by upward deflection of winds by land or cold atmospheric barriers, or by warmer air underrunning colder air; in other words, by forced convection. Mixture of warm and cold air may have some part in their formation.

Fracto-nimbus. These are popularly known as "scuds." They are detached fragments, fog-like in appearance, often appearing lighter than the nimbus background. They are usually drifting rapidly at altitudes of 300 to 1000 feet. They seem to form only when a strong wind is blowing.

Cumulus. These are often called "wool-pack" clouds. They are detached clouds with rapidly changing dome-shaped crests similar to cauliflower heads. A characteristic of these clouds is the flat base at the saturation level. Its sunlit portions are a brilliant white or yellowish white against the blue sky. Their great thickness accounts for the beautiful gradations of shading from the dark shadows to the brilliant highlights. The average altitude of the base is about 5000 feet

and of the crest about 7000 feet. They are produced entirely by vertical convection currents due to temperature differences, consequently they are frequent in the tropics and over continents of the temperate zone in summer. They appear over land most abundantly in the afternoon and over the sea late in the night. Sometimes they form a coastal fringe which shifts a few miles to sea in the night and a few miles inland during the day, attending the land and sea breeze. They often are to be seen over islands and reefs thus revealing the presence of these while still below the horizon. They have been seen to parallel lakes and large rivers.

Fracto-cumulus. Often these are undeveloped cumuli appearing somewhat tattered but sometimes they are torn from the top of the cumuli. If a towering cumulus is closely watched a thin fragment will sometimes be seen projecting gradually from it. It appears like a banner until detached and shortly it will be floating alone. The birth of these fracto-cumuli is one of the interesting sights of cloudland. Sometimes as cumulus clouds float in from over a large body of water on a hot day they are quite severely torn by the vertical convection currents over the land. The land is hotter, hence the severity of the vertical convection currents which detach pieces of the cumulus thus forming fracto-cumuli.

Cumulo-nimbus. This is the thundercloud which is the accompaniment of every thunder-

storm. It is a cumulus cloud from which rain is falling. Many are sometimes massed in the form of huge mountains, towering majestically as high as 45,000 feet. The base of such clouds resembles the nimbus and is at about the same elevation, usually about 4000 feet. Rising out of this nimbus is the towering mass of turbulent cumulus clouds around whose peaks there often float false cirri. Sometimes there is a fringed appearance to the edges. Local showers of rain, snow, and occasionally hail fall from this type of cloud. The front of extensive thunderclouds of an approaching storm usually appears like a bow-wreath spread across the sky from a view-point on earth. This is sometimes called a squall-cloud.

Stratus. This is a low horizontal sheet of fog often merging into a nimbus cloud. Its altitude usually varies from 1500 to 3000 feet. Sometimes it is merely a sea-fog drifting over the relatively warmer land. It is often due to a layer of cold air underrunning a layer of warmer air and sometimes perhaps to a mixture of relatively quiet layers of humid air of different temperatures.

Fracto-stratus. As the stratus cloud is shredded by the winds or broken up by the summits of mountains the fracto-stratus is formed.

It is fascinating and instructive to watch these various cloud-forms evolving from one form to another; to analyze the different air-currents and to visualize their relative temperatures and humidities as the clouds form from the clear trans-

parent air or as they disappear by evaporation. Observation and study of cloud-forms and cloud-meanings become even much more fascinating through the intimacies gained in flying among the clouds. Cloudland then becomes a fairyland of beauty and interest.

The types of clouds described in the foregoing paragraphs are sufficient, with their many transitional forms, to meet the requirements of ordinary cloud study. However, there are a number of special forms which are so characteristic that it is convenient to have names for them.

Billow clouds. These are sometimes called "windrow" or "wave" clouds. They occur in series of bands generally with intervening strips of clear sky. They look like waves or billows on water and are formed in quite a similar manner. They are produced by the flow of one layer of air over another of different temperature, density, and humidity. When one stratum of air flows over another layer of different density or humidity, cloud-billows of great wave length are developed in the same manner that winds produce ocean billows. These billows are often of great depth from crest to trough. Obviously, great billows may exist unseen in the air unless the conditions are satisfactory for the formation of clouds. As a series of waves develop, the air involved rises and falls and is subjected to alternate heating and cooling, with maximal and minimal temperatures corresponding to the troughs and crests respec-

tively. If the humidity is great enough so that the air at the trough is just saturated, moisture will condense above the trough, namely at the crest. Thus the billows of air become visible in cloud and the troughs being clear, the strips of blue sky separate the individual waves from each other. It is interesting to note that the billow cloud must be rapidly evaporating on the rear or descending portion of the wave and as rapidly forming on the front or rising portion. This must be the case inasmuch as the waves or billows are driven onward as they are in water. These billow clouds form usually in the lower cirrus region, at 20,000 to 25,000 feet, but they may occur at any altitude. In fact, even surface fogs are sometimes billowed as well as the highest cirrus clouds.

Lenticular cloud. As the name implies, this cloud resembles a lentil in form or its cross-section is similar to that of a double-convex lens. It is formed by the upward deflection of air by mountain peaks and possibly by rising air-currents. The low temperature of the peak itself doubtless plays a part. The cloud particles are rapidly evaporated as they are carried away by the wind but this loss is constantly being replenished. This, then, is a stationary cloud which is constantly being renewed. It, like many other clouds, is permanent in quite the same sense that a cataract in a stream is permanent through the continuous supply of water by the source and stream above.

Crest cloud. This is formed by the upward de-

flection of wind by a long mountain range and often covers the upper slopes and the top. It appears as a crest cloud only to those in the lowlands, for it is designated as fog by those living in it. This is, of course, quite natural. The maintenance of this cloud is similar to that of the lenticular cloud.

Banner cloud. This resembles a white banner floating from a high mountain peak. The same effect may be seen occasionally in the case of the towering cumulus or cumulo-nimbus. When the winds are strong the pressure to the leeward of a mountain peak is somewhat reduced just as the wind blowing across a chimney-top reduces the pressure in the chimney. This reduction of pressure results in a lower temperature. When this temperature is below the dew-point in this somewhat rarefied pocket, condensation takes place. It is seen that this cloud is being renewed constantly on the windward side as it evaporates on the leeward.

Scarf cloud. Occasionally as a cumulus cloud rises rapidly due to powerful vertical convection to a great height, a thin cirrus-like cloud, convex on the upper surface, forms above the cumulus crest. At first this appears to be entirely detached but later as the cumulus continues to rise, this cloud extends more and more, finally resting upon the crest and later draping over the sides of the cumulus. It resembles a silken white scarf or mantle. It is due to elevation, expansion, and

cooling of the air above the rising cumulus. Generally the elevating of this upper air does not result in the formation of cloud; however, when there is a thin stratum of nearly saturated air in which an alto-stratus may form when it is lifted bodily by the rising cumulus, the scarf cloud results. If this stratum of saturated air is thin the cumulus cloud may rise far above it. The relation of clouds with clouds is even more interesting than the association of clouds with mountains.

False cirrus. This name is applied to those clouds combed out from the towering thunderheads by the high winds of the upper regions. Despite the comparative calm of lower altitudes when cumuli are conspicuous, it occasionally happens that a towering cumulus reaches an altitude of high wind-velocity. The crest may be drawn out into fibrous wisps of ice crystals. This is a real cirrus cloud from all viewpoints except, perhaps, its manner of origin from which the name is derived.

Mammato-cumulus. When the base of a cloud shows downward projection bosses, the prefix, mammato, may be used. Sometimes such clouds are called pocky-cloud, sack-cloud, festoon-cloud, rain-ball, draped-veil cloud. The individuals of a group of these resemble in shape small reversed cumuli. This formation generally occurs in conjunction with a severe thunderstorm in a cumulo-stratus or an alto-stratus cloud. This unusual formation may result from a cold layer of snow

(for hail and snow often occur in the upper portions of towering cumuli) drifting out over a stratus cloud. This cool layer may descend at many places and each of these descents will produce a sag in the base of the stratus cloud.

Tornado. This cloud, which makes it possible to see the whirlpool of winds comprising this terrific storm known as the tornado, is characteristically funnel-shaped. It appears to be an extension of a cumulo-nimbus and is produced by the cooling due to the expansion which results from the rapid rotation of air in the funnel. The velocities of the air in parts of this funnel are said to attain the value of 500 miles per hour. It is a storm peculiar to the United States and most prevalent in the middle west. This cloud fortunately is rare for a given locality but when once seen with its attendant destructive power, it instills an awesomeness or terror which impresses the picture upon the mind for a life time. It is the smallest, briefest, and fiercest of storms.

CHAPTER VI

BEYOND AN OVERCAST SKY

"There the sea I found
Calm as a cradled child in dreamless
slumber bound."

—SHELLEY.

YESTERDAY thin fibrous clouds barely showing against the blue came out of the west and passed rapidly on the highways of the winds across the heavens. In the course of an hour they spread across the sky like silken white tresses blown in the wind. These are the "mare's tails" of the landsman and the "cat's tails" of the mariner. Owing to perspective they appeared to spread upward and outward from a source below the western horizon, but this was an illusion, for they were practically at a uniform level. They were the high cirrus clouds which are born in the cradle of a cyclonic storm and go forth driven by the high winds of their altitude to foretell the approach of the storm-area. Over in an adjacent territory, perhaps hundreds of miles to the west, there is an area of low barometric pressure. This is the center of the region of the cyclone—a sys-

tem of winds surrounding this low-pressure area. This cyclone is ordinarily very extensive, its diameter averaging about 1500 miles. Strong winds and heavy precipitation are associated with this area of low barometric pressure. The filmy cirri owe their origin to the vapor-laden air which is sent to high altitudes by the strong updraft or convection currents in the rainy portion of the cyclonic areas. This moist breath often reaches altitudes as high as seven miles where the temperature may be as low as 50° Fahrenheit, below zero, hence the cirrus clouds always consist of ice crystals. Their tenuous character is due to the fact that little moisture can reach such altitudes. Having been thus formed, they are carried forward at a tremendous speed, for the velocities of the winds at these high altitudes are sometimes as great as two hundred miles per hour. Thus these thread-like streamers born in the storm-area, herald the approach of the storm itself many hours before it arrives, for the cyclone travels at a much slower velocity, ranging from twenty to thirty miles per hour.

As time elapses after the first appearance of these messengers speeding on the winds, the clouds gradually become denser and denser. To those skilled in reading the weather-signs, a general rain or snow is almost a certainty in from ten to thirty hours. These filmy cirri appeared yesterday so it is not surprising that to-day dawned rainy and dreary. The ground is saturated, rain

ABOVE A THICK BLANKET OF RAIN-CLOUD

is drizzling, the ghostly scuds are rapidly drifting beneath the heavy nimbus at an elevation of a few hundred feet. The aircraft with its delicate wings is snugly housed and two airmen sit in the doorway discussing the weather prospects. Above that dark heavy layer of cloud, extending as far as the eye can see, are blue sky and sunny weather. Again Nature has imprisoned mankind underneath a damp dark blanket and has arranged for a dreary day. The airmen are restless; they resent this tyranny. Scanning the sky carefully they note in the distance a lighter area which suggests a stairway to the sunny roof. To reach it means a somewhat hazardous flight at an elevation of less than a thousand feet and some of the distance is over a large area of water. Is it worth the risk to climb this stairway to the freedom of space and sunny weather? They agree that it is; the aircraft is drawn from its snug hangar, and the engine is warmed up in the misty air. Every precaution is taken, for the motive power must not fail in the pinches ahead. They take-off and in a few moments are among the scuds. In order to gain the safety of as much altitude as possible they climb to the base of the apparently infinite area of the dark nimbus cloud and head in a straight line for the brighter spot hoping that they will be greeted by the blue sky above. They fly so close to this dismal ceiling that at times the earth is blotted out by its clammy fringes, but onward they go by the compass toward their promising

doorway. They arrive and find an open space, but what a distance to the sky! They enter and begin their winding climb, for the hole is not large. For fifteen minutes they mount up and up this winding stairway which proves to be one mile in depth.

They emerge in dazzling sunlight above a layer of cloud a mile in depth and spreading in all directions as far as the eye can reach. Continuing their way upward, this jagged surface unfolds before them apparently to infinity on all sides. It resembles a polar sea of snow and ice. Even the pressure ridges are present and it is as white and bright as the purest snow. If it were not for the roar of the engines they might even expect to hear the grinding and booming of the pressure ridges of arctic ice. Above them is the dark blue of a dust-free sky. Byron might have been describing this when he wrote,—

> "And they were canopied by the blue sky,
> So cloudless, clear and purely beautiful,
> That God alone was to be seen in Heaven."

This sentiment and mood is appropriate, but that deep, quivering, transparent void of penetrable space is so blue that one desires to repeat and repeat with Southey, "Blue, darkly, deeply, beautifully blue." In this trembling transparency it is easy to imagine faint veiled vestiges of dark vapor intermingled with spots of deceiving light which give to this infinite solitude as seen from above the smudge of the lower atmosphere, a vi-

brating depth never represented by the master in flat dead color.

The sun is radiantly bright,—"God's crest upon His azure shield, the Heavens." The entire earth is shut out below them hidden under a deep vaporous blanket, glowing with intense brightness above but as dark as rain clouds can be on the lower side. What a contrast between the earthly world and that of the airman! The dark ultramarine canopy overhead is unseamed by even the faintest cirri. It expresses the serenity of the solitude of space. How the airmen long to quiet their craft in order to feel this utter silence! The engine's roar is greatly decreased by throttling the fuel but the whir of the wires and struts of the gliding craft is loud in this solitude whose silence is expressed by the blue quietude above and the white calm below. They wish for a balloon and its comfortable basket, commonly disdained by them, for here is its ideal place. It would be heavenly to drift in the sunlight amid the absolute silence.

The airmen circle about the opening of their stairway as they mount higher and higher. At ten thousand feet they still see an endless ocean of snow-white cloud below them unbroken except for their stairway to earth. They fly here and there but return often not without anxiety to their exit, for it must not close up. If it did they would be in a serious plight, for to bore down blindly through a mile depth of cloud which reaches

within a thousand feet of the earth would be full of hazards with the odds against them. An airplane requires little attention to keep it on an even keel. The pilot uses the horizon, whether land, sea, cloud, or haze, for the purpose of maintaining an even keel. This is done as subconsciously as the autoist manipulates the steering-wheel and keeps in the roadway. But when the pilot has no horizon and is in blinding cloud or fog, his sense of balance fails him. Gravity still operates, but the lack of uniform velocity of the airplane under the conditions of flying in absolute darkness or in a dense cloud makes instruments such as levels almost useless. If the airplane turned over so that it were gliding upside down, the airman would know this by the rush of blood to the head or by the consciousness of hanging by the belt. Under these conditions where no horizon or other definite reference line or point is available, the airman knows when he is upside down but *not when he is right side up.* On descending through a deep layer of cloud such as this overcast blanket, the craft might emerge from the lower side in a dangerous position at a terrific velocity and insufficient altitude would remain for gaining control over the craft. The airmen know fully well the danger which would confront them if their exit should close and they are ready to "spiral" downward hastily or even to nose-dive a few thousand feet if the urgency should require it.

The exit shows no signs of closing so they con-

tinue their circling in this strange world. They catch a glimpse of their shadow cast upon the brilliant white surface below them. It is not an ordinary shadow, for it is fringed with rainbow colors. What a beautiful phenomenon! They are ready to believe that they are in dreamland or in the land of Jules Verne where multi-colored halos or aureoles might be commonplace adornments for lords of the aerial kingdom. But one of them recollects that back in his past when he was taught physics he acquired the information that such a phenomenon was the result of diffraction or refraction of light under certain proper conditions. It then occurred to him that tourists in Switzerland arise very early in the morning at a certain place in order that they may stand on the eastern side of a valley at sunrise and see, cast on a fog-bank, their elongated shadows fringed with rainbow colors.

This shadow is the only moving thing in the entire panorama, for the slow movements of the jagged surface of the cloud layer below are not apparent owing to the speed of the aircraft. The scenery is monotonous but the mood is hypnotic. It is difficult to force a withdrawal from this sunny though inexpressively unreal world to that dreary one hidden beneath. However, all this time the extensive blanket of clouds has been drifting and the cloud-lined stairway by this time might emerge miles away from safe landing, so they reluctantly glide toward their exit. They dip into it and

rapidly descend in a close "spiral." The field is ten miles away in the murky distance and the air is saturated with chilly dampness. In a few minutes they glide to earth splashing through water puddles, and stop before the hangar. The faithful craft is snugly housed again and the two airmen seat themselves in the doorway. The earth is wet and dark and dreary but they are living in their imaginations in that sunlit blue-canopied solitude a mile or more above them.

CHAPTER VII

CLOUD-LEVELS

"I am the daughter of Earth and Water,
And the nursling of the Sky;
I pass through the pores of the oceans and shores;
I change, but I cannot die."

—SHELLEY.

THE observer of the sky learns by the forms, velocities, and various characteristics of clouds to judge their levels and instinctively he relates to the various distinctive cloud-levels certain patterns, sky-moods, types of beauty, and approaching weather conditions. The observant aerial traveler through the accumulation of experiences during his more intimate associations with the clouds learns all these things more definitely. Clouds may mean joy, danger, or even disaster to the airman, therefore he is forced to consider them. He instinctively learns to expect certain formations at various levels; to judge the extent of the cloud-mass which he may be approaching; to visualize the air-currents from cloud-forms; to estimate temperatures at various levels to some extent by the positions and forms of

clouds; to judge the thickness of a layer of clouds which may be below him; and to some extent to ascertain whether he is over land or sea or to judge the chorography of the region below him by the character of the clouds and fogs. All aerial travelers will not be so observant as to become skilled in interpreting the clouds but those who would become learned in the ways of the aerial world will observe these sign-posts on the aerial highways and learn their meanings. They will thus become proficient in interpreting the language of clouds.

Clouds exist at various times throughout the entire space from the surface of the earth to an altitude of seven miles. On rare occasions they have been observed to be as high as ten miles. Furthermore, they speed along borne by winds ranging in velocity as high as two hundred miles and even more per hour. But notwithstanding this apparent chaos there are laws for them and order among them which the aerial traveler will be able to detect and to utilize. Suppose that all the clouds of a given season could be recalled to their places. Then the seven-mile layer of atmosphere would be perhaps nearly an unbroken mass of clouds, but if the density could be measured throughout the entire range of altitude, certain defined levels of maximum density would be found. Instead of depending upon this impossible expedient, the regions of maximum and minimum cloudiness may be determined approximately by

WIND-DRIVEN CIRRI ABOVE; ROLLING CUMULI BELOW

observation during many successive journeys in cloudland, but better still, by grouping and averaging the cloud data which have been systematically recorded by meteorologists. It is of sufficient importance and, it is hoped, of enough interest to present a discussion of cloud-levels. In a way, the discussion will be a summary of certain aspects of clouds grouped in a manner to obtain another view of clouds, their courses, forms, heights, and meanings.

By tabulating the frequency of appearance of various clouds with reference to altitude, season, and locality, the regions of maximum and minimum occurrence are obtained. In general, a condition which tends to increase the relative humidity also tends to lower the cloud-levels. For this reason, the various types of clouds are generally lower over sea than over land, lower over humid regions than over large deserts, lower in winter than in summer, and lower at high latitudes than at those nearer the equator.

If a cloudy day could be made to order in a middle latitude such as that of the United States during which the general types of clouds were distributed according to elevation and density in a manner to represent a true average condition, the airman would find definite cloud-levels if he were able to explore a vertical section of the atmosphere throughout its extent to an elevation of seven miles. The airman as he ascended on this flight would record the following approximate ele-

vations pertaining to maximum and minimum cloudiness:

A maximum,—fog level, at or near earth's surface.
A minimum,—scud region, up to 1000 feet.
A maximum,—cumulus level, about 5000 feet,
A minimum,—intercumulus region, 8000 to 12,000 feet.
A maximum,—alto-cumulus region, 13,000 feet.
A minimum,—alto-stratus region, 13,000 to 19,000 feet.
A maximum,—cirro-stratus level, about 26,000 feet.
A minimum,—intercirrus region, 28,000 to 31,000 feet.
A maximum,—cirrus level, about 33,000 feet.
A minimum,—the stratosphere or isothermal region, above 36,000 feet.

Owing to the fact that it is generally easier to determine the elevation of maximum and minimum cloudiness, the former are expressed as "levels." Between these "levels" lie the "regions" of minimum cloudiness.

The foregoing makes it easy to visualize the general disposition of clouds throughout the seven-mile depth of atmosphere which is inhabited by them. It is seen that there are five levels of maximum cloudiness between which, and above the last level, five regions of minimum cloudiness are interspersed. This mental picture is of interest as a whole but it appears of interest to discuss each level or region even at the risk of some slight repetition of portions of other chapters, because each has its own characteristics. These further details should aid the traveler in cloudland to understand its ways.

Fog level. A fog is a cloud on earth and differs in general from a cloud only in its location. It is formed in two ways as will be seen. It often forms along lakes, rivers, and creeks and even in streamless valleys, on calm, clear nights especially in autumn. During a calm day the lowest stratum of air has accumulated much water-vapor, and owing to the calmness much of this air remains in its low position after nightfall. This humid air and the earth beneath radiate heat to space owing to the clearness of the sky during the calm clear night and when the air loses sufficient heat to lower its temperature below the dew-point, the water-vapor condenses on the dust particles and a fog results. Such a fog is not likely to form on a cloudy night because the air will not ordinarily cool sufficiently. On windy nights the humid layer is mixed with dryer layers decreasing the resultant humidity; furthermore, the air is not liable to remain for a sufficient period over a cold surface to have its temperature decreased to the dew-point.

Another general mode of formation is by the drifting of humid air over a cold surface and being cooled by loss of heat to that surface. When cooled sufficiently so that the temperature of the air is below the dew-point, a fog results. The effect of air-currents operates on small and large scales. Fogs may trail along a river or valley or may cover a lake. On a larger scale fogs are produced by ocean breezes blowing over areas of ice

and snow. If humid air over a warm ocean current, such as the Gulf Stream, be diverted over a colder surface, some of its water-vapor will be condensed and an extensive fog will be the result.

From such a knowledge it is often easy to account for the formation of clouds in the various strata of atmosphere far above the surface of the earth because the same processes take place in the formation of clouds. Furthermore, the airman may be able to judge the topography of the earth's surface when obscured by fog, and perhaps accurately to guess the presence of a lake or river which he may be anxiously waiting to "pick up."

Scud region. The lowest level of maximum cloudiness being at the earth's surface and the next level at approximately 5000 feet, the approximate average elevation of the base of cumulus clouds, the intervening region is one of minimum cloudiness. The elevation of the actual "minimum" would be just above the highest fog. The name "scud region" may be logically applied because the "scud" is the only frequenter of this region with the exception, perhaps, of the lower portions of nimbus clouds.

Cumulus level. The foul-weather type of cumulus, including the cumulo-nimbus, is produced by vertical convection currents. The clouds do not form until the humid air reaches elevations above the saturation level; that is, until the point is reached where the air is cooled below its dew-point. This level is denoted by the flat bases of

the cumulus clouds. If the clouds drifted or settled below this level they would simply evaporate. In fact, these clouds are continually evaporating and are being replenished from below. The vertical convection is usually due to air being warmer and therefore lighter than surrounding air. As this humid air expands it cools below the dew-point and is further cooled when the water-vapor condenses. These clouds do not extend as high as the fair-weather types which are formed from air in which the relative humidity is low. The bases of foul-weather cumulus clouds are at an elevation of approximately 5000 feet and their crests at approximately 7000 feet. This is the second level of maximum cloudiness.

Intercumulus region. This region is that bounded by the foul-weather cumulus level below, and by the fair-weather cumulus, or alto-cumulus level. It lies approximately between 8000 and 12,000 feet.

Alto-cumulus level. This is the level of the fair-weather cumulus clouds which are formed during fair, calm summer weather by strong vertical convection currents. Owing to the low relative humidity and strong convection, the water-vapor does not condense until a generally higher elevation is reached than that sufficient for the formation of the foul-weather cumulus clouds. Hence the alto-cumulus clouds are approximately at a level of about 13,000 feet, which is the third level of maximum cloudiness.

Alto-stratus region. This region is bounded by the level of the alto-cumulus clouds below, and above by the level of the cirro-stratus clouds, hence it lies approximately between elevations of 13,000 and 19,000 feet. The scarcity of clouds in this region is due to several reasons. It is above the level of diurnal convection currents; hence, practically no cumulus clouds are formed in this region. Many clouds are born in cyclone areas but those of this intermediate level are not distributed as rapidly or as widely as the cirrus clouds owing to lower velocities of the winds in this region than in the region of the cirri. During the periods of anticyclones the air in this region is usually dry, hence no clouds are formed.

Cirro-stratus level. This is the fourth level of maximum cloudiness or cloud-frequency with an average elevation of about 26,000 feet. The frequency of clouds at this level is due chiefly to the high winds which distribute far and wide these clouds which are born in the cradle of the cyclonic storm center.

Intercirrus region. This region is bounded below by the foul-weather cirrus clouds formed in the cyclonic area, and above by the fair-weather cirrus clouds. The average elevations of these two types of cirrus clouds are approximately 26,000 and 33,000 feet respectively, so that this region may be considered to lie, say, between 28,000 feet and 31,000 feet.

Cirrus level. This is the fifth and highest level

of maximum cloudiness or cloud-frequency. During fair weather, filmy cirrus clouds form at the high altitudes below the stratosphere due to the cooling of this upper atmosphere which accompanies a high barometric pressure. Their average altitude is about 33,000 feet, hence this is a level of maximum cloudiness.

The stratosphere. Above the level of the highest cirrus clouds very little water-vapor exists. This is the region beyond any appreciable convection; hence, clouds seldom form in this region which lies beyond an elevation of about 36,000 feet for middle latitudes. In the portion of this region which has been explored by means of recording instruments carried by small balloons filled with hydrogen (up to about twenty-two miles) the temperature appears to be nearly constant; that is, it does not decrease appreciably with altitude.

In the foregoing descriptions the altitudes are only approximate, for it is impossible and fortunately unnecessary to reduce the levels to a very exact figure. The descriptions as given serve the purpose of this chapter which aims to present another viewpoint pertaining to the appreciation, study, and interpretation of clouds.

CHAPTER VIII

MINGLED MOODS

"Clouds on clouds, in volumes driven,
Curtain round the vault of heaven."
—THOMAS LOVE PEACOCK.

IT is one of those occasional days when Nature seems to be uncertain of purpose. For a time a scowl passes over her countenance and gusts of angry rain fall, then as if weakening in her resolution, she draws the dark curtain apart and the sun smiles through. Yonder, thin, pale, fragmentary clouds, torn by the gale from the nimbus which hangs over the west, are speeding down the wind. Passing successively in shadow, diffused light, and direct sunlight, these wind-blown fragments appear like moving opals. To the east are brighter fracto-cumulus clouds like tufts of wool torn by the winds. Far above them is a billowed layer with patches of deep blue sky showing in the interstices. As the fracto-cumulus clouds are driven before the wind, the succession of lights and shadows cast by the billowed stratum upon them give to them a changeableness in light, shade, and tint befitting the mingled moods of the

IN THE TURBULENCE OF THE CRESTS OF HUGE CUMULI

whole sky. Above all these, streaks of cirrus or cirro-stratus clouds are visible here and there. The movements of these various clouds at different velocities and in several directions combined with their ever-changing tints and brightnesses give to the sky the appearance of a huge stage amid the excited haste of preparation for a performance or of the clearing after one. But from the weather reports no general storm is brewing. Nature is merely indulging in a playful mood, doing this moment and that just what her temperament dictates.

It is a rare day for the aerial traveler to see the shifting of the scenery of cloudland. Flying on clear days is dull compared with those marvelous days when broken clouds are ever-changing in form and color. Cross-country flights on clear days are delightful owing to the changing panoramas but even on such days, a way-side flock of clouds is welcomed for the variety it introduces. However, on those fitful days when many types of clouds are present at various altitudes, the delights of an hour in cloudland are immeasurable. On such a day the aerial traveler is greeted with a new setting every moment.

Heading into the strong breeze which is but a reminder of the battling winds above, two airmen take to the air. Their course is directly toward the scowling nimbus to the west which is showering the earth beneath. The day is chilly and not conducive to the formation of towering cumulo-

nimbus or thunderclouds which might lash the earth with rain and hail. Little danger lurks in the heights above, despite the uncertain aspect of the sky. Rising higher and higher, they note the brighter spaces beyond the frowning nimbus which means that the shower to the west is merely a local one. Circling back in their climb they approach the lower level of the cloud from which a fitful rain is falling a few miles to the west. Already they have passed through the scudding fragments torn from the rain cloud. As they continue to climb, they soon approach the region of the torn fragments of cumulus clouds which are speeding eastward in a gale. These clouds are rolling or tumbling as the upper portions are driven ahead of their bases which are retarded by the slower winds of the lower altitude.

Banking stiffly, the airmen head their craft again to the westward to fight the strong westerly wind. They are now at an altitude of about a mile and are entering the region of the tattered cumuli. Up and up they climb and attempt to steer their way between these clouds. How wonderful are these intimate associations! The woolly clouds with wind-blown edges are all around them like icebergs in a dark sea. Some are warmly bright in the sunshine; others are coldly dark in the shadows cast by the clouds above. But all of them hold the same straining attitude as if they were racing each other. They lean forward as if urging onward by sheer will-power their lagging

extremities. Despite their attempts to steer clear of these vaporous bergs, occasionally as the airmen circle back in the constant battle with the strong west wind, they collide with one of them. The collision is noiseless and unfelt, but for a few moments they are blinded as they pass through this lump of fog. The air is "bumpy," for the eddies and battling currents made visible by the clouds buffet the aircraft gently.

As the airmen reach an altitude beyond the crests of these straining racing clouds, they enter an open space, but far above them, floating upon the blue sea, are the beautiful symmetrical patterns of the billowed clouds. This high stratum appears nearly stationary, but this is because of its height or distance. Even still higher, streaks of cirrus clouds are visible between the billows. Toward the west appears the rounded top of the cumulo-nimbus poking its crest above the level of the fleeting cumulus clouds. Bathed in sunlight with the small shadows of the upper clouds flitting over its brilliant vaporous head, it is a beautiful sight. It is difficult to visualize this snow-white crest as a part of that dark cloud which the airmen saw a few minutes ago frowning and shedding rain upon the earth. Here in the varying light it is as snow-white as the clouds surrounding it. By contrast with these upper surfaces, the high clouds are now gray although from the earth they appeared bright, cheerful, sunlit bits among the darker clouds of the lower

levels. Far and wide beyond this rearing cumulo-nimbus, the small fracto-cumuli lie scattered like patches of ice floating in a dark greenish sea. Their brilliant white surfaces, through contrast, make the earth appear dark and foreboding and they have been flattened by distance, for the airmen have mounted far above their level.

As they reach an altitude of 10,000 feet they clear the top of the cumulo-nimbus from which rain is falling. Far above them, perhaps at an altitude of 15,000 or 20,000 feet is the sheet of billowed cloud which so picturesquely makes visible the intricate currents of the air. The airmen note by the drift of their craft that they are now in a cross-current of air. A few stray bits of fog-like clouds float just above their level, survivors, perhaps, of alto-cumuli or rearing cumuli which may have passed along recently or which may have partially evaporated on meeting the thirsty air of a cross-current. The space immediately surrounding them appears to offer no more clouds to visit. The billowed layer above, which trails off toward the horizon in fore-shortening waves and ends in an apparently even layer, is too far above them to consider at present. However, there lies to the northward at an elevation somewhat above them, a thin flat cloud which appears interesting.

They head their craft toward this and are borne rapidly toward it in the strong wind. As they approach it they note a white film-like veil pen-

dent beneath it and this shines brightly in the sunlight. As they gain an elevation somewhat above it they note that its upper surface is slightly irregular and beautifully white. The thin white veil draping from its lower surface extends downward for about 2000 feet and from its unpatterned textureless character they conclude that it is rain falling from the flat cloud. A glance at the thermometer contradicts them because it is registering several degrees below freezing. Then it must be snowing! Here in the summertime, at an elevation of slightly more than two miles, a snowstorm is taking place in the aerial world, unnoticed and unfelt by mankind below. They dip downward toward this pendent veil and shortly they enter it. For a few damp moments they are blinded, but they soon emerge in the clear sunlit atmosphere below. They have passed through falling snow and then rain in these few moments, but where does the snow fall? It falls about 2000 feet from its source in the flat sheet above and is then devoured by the cross-current of relatively dry air which it meets. How often such aerial events take place without being heeded by mankind on earth! From high clouds filmy tufts sometimes appear to be hanging like white whiskers. These may actually be falling rain or snow which is evaporated as it meets a stratum of air whose relative humidity is low.

Many other interesting events lie within the range of the airmen on this fitful day but they

are out for only an hour or two. The billowy layer above them is too high for this trip. As they gaze upward for a parting glance before they descend they note that it has changed. The billows are now almost invisible. Over a portion of the sky they have apparently evaporated, exposing the higher filmy cirrus clouds clearly to view. Over the remaining portion they appear to have coalesced into a thicker mass which is seared with bold stream-lines of light and shade, appearing as if this thickened mass were drawn out by a powerful wind. Thus the conflicting winds, varying in their appetites for water-vapor, mould or devour the clouds as they please.

The airmen dip the craft downward at a gentle glide and steer toward the rounded cumulo-nimbus which marks approximately their field. The same pattern of tattered cumuli lies below them. From this high altitude they appear flattened, hence they lie like ice-cakes on a dark sea. From a lower altitude they assume a third dimension and appear more like white bergs. Vertically below them these fragments are scattered, but far toward the horizon whence they came, they appear en masse. In the distance toward which these clouds are traveling they also appear packed as if there lies the rendezvous of the assembling cohorts.

As the airmen approach the rearing crest of the cumulo-nimbus it is seen to be much changed in appearance. Instead of the compact rounded

crest, many crevices appear. The huge cloud-mass is disintegrating after having performed its office. At its crest a white banner develops and begins to strain in the wind. The high wind at this level is tearing a piece from the crest of this thunderhead. As this fluttering straining banner elongates it seems to be drawn more and more rapidly until soon it becomes detached. It drifts rapidly away from its parent, an isolated tattered fragment launched by the wind upon a brief career. It may travel far before it vanishes or loses its identity by merging into a mass of cloud, but likely it is destined soon to be drunk by a thirsty wind. Perhaps at best, it will evaporate with the approach of night, disappearing like a spirit into that invisible aerial world whence it came.

The large crevices in the thunderhead widen and deepen and soon large masses are separating as if to wander again at play with the winds after having faithfully gathered to bestow the blessing of rain upon the earth. The day is waning and with it the strength of the vertical convection currents diminishes. The cloud in performing its duty also has suffered internal modification. No longer reinforced by the upward currents, and having performed its office, this huge assemblage is adjourning. Its disintegration into masses of various shapes and sizes is one of the worthy spectacles of cloudland.

The oblique rays of the sun dimly illuminate

the haze and mist in the depths of these clouds and the blue light from the sky combining with this light gives a purplish tinge to these depths. The side of the cloud in full shadow is a bluish shade and the sunlit crests are white. The color contrasts, the variety of pattern, and the modulations of light and shade in the oblique sunlight combine to give these clouds a high place among the sculptures of cloudland.

All these things and many more the observing airmen saw in an hour or so on this day of many moods. Through the combination of observation and knowledge, the aerial world becomes a place of ever-widening interest. As they glide downward and come to a safe landing it is difficult for them to believe that they left the earth such a short time ago, for in that brief sojourn aloft, the weather conditions of a cycle of seasons were experienced. Besides these, the beauties, wonders, and interesting phenomena of another world greeted them every moment. As they walk homeward they glance at the opalescent sky and wonder if they will ever exhaust this source which so far has been one of intense and perpetual interest.

CHAPTER IX

SUNSET COLORS

"Die down, O dismal day!
And come, blue deeps! magnificently strewn
With colored clouds—large, light, and fugitive—
By upper winds through pompous motions blown."
—DAVID GRAY.

DISMAL indeed is the glorious day compared with the radiant splendor of the setting sun. Is it mere fancy that the thick veil which hangs in the sky all day long thins or parts for this nightly benediction? Is it mere fancy that a sky which has remained serene and cloudless all day long is visited in the west by at least a few clouds to add something to this *au revoir?* Seldom is the observer disappointed who looks toward the west at the appointed hour, for here in its variety of color, pattern, and mood is the silent benediction. Doubtless there is always a tinge of sadness to this splendid scene but scarcely sorrow. Herein lies the difference between certainty and uncertainty. The death-bed of life is shrouded in deepest sorrow but that of

the day is beautiful. The sun will rise again on the morrow—that is certain.

Of those millions who gaze at the sunrise and sunset and note its complexity of color, changing from moment to moment, are there many who know that the cause is simple? It does not add to the beauty of the display to know the reasons, but it adds an interesting phase to the pleasure of observing and of studying the phenomena of the sky. To the aerial traveler who soars upward from one cloud level to another, as the sun is setting, the scheme of coloring is simple. At an elevation from which he is able to look down upon some layers, along the level of another, and up at the remaining layers, the whole scheme of the painting of the sunset is laid bare. The arrangement of colors on Nature's palette is very elementary.

When the sun is high in the heavens there are two chief sources of the colors which the clouds display, namely, the sun and the sky, but superimposed upon everything is the bluish color of the earth-haze. When looking vertically upward from the earth or vertically downward from an aircraft at high altitudes, the observer looks through about a mile depth of haze ordinarily. However, this depth rapidly increases with the obliquity of vision; hence, the color of objects immersed in or beyond the haze will depend partially upon its color and this color deepens with the depth of the haze. The clear sky, of course,

is a deep blue outside the earth's haze and noon sunlight may be considered to be white. However, by contrast with the blue sky, the sun or sunlit white clouds appear yellowish. The effect of this contrast may be eliminated by looking at a sunlit cloud through a hole in a black cardboard held at an arm's length. The effectiveness of this contrast in making the white sunlit clouds appear of a yellowish tint is obvious to the observant aerial traveler. The same sunlit clouds which against the sky appear yellowish appear white when viewed from above against the dark dull tertiary earth-colors.

The portions of clouds in shadow will receive skylight predominantly, hence the bluish appearance of these shadows. The thinner the clouds are, the lighter the shadows. In these cases some diffused sunlight reaches the shadow through the cloud and is mixed with the blue skylight. Dense haze often appears to assume a purplish tinge. The effect of the haze can best be understood and visualized if it is studied first by the example of cigar smoke, for the earth-haze consists chiefly of dust and smoke carried upward largely by the diurnal convection currents. Furthermore, smoke consists of carbon particles and is similar to dust.

If one stands in the sun near a white surface and observes the shadow of a dense cloud of smoke cast on a white surface, it will be noted that the smoke alters the sunlight in a manner similar to a brownish glass. At this point it is

well to recall that sunlight contains light rays of many colors whose combined action upon the visual organ produces the sensation of white, but if the quantitative relation of these colored components is changed, the combined color is in general altered. The principal components are seen in the rainbow; by means of the refractive property of the raindrops the heterogeneous sunlight has been separated into its components, which are chiefly violet, blue, green, yellow, orange, and red. A red glass transmits the red rays principally, hence through it a white object appears red. A white object will also appear red if it is illuminated by red light. The first case is in reality the same as the second because the other colored components in the light in the first case are ineffective owing to the fact that the red glass does not permit them to reach the eye.

It follows from the foregoing that the cloud of smoke casts a reddish or brownish shadow because it partially obstructs the blue and violet rays. This obstruction is caused partially by actual absorption and partially by scattering the violet and blue rays more than the other components. If the cloud of smoke be observed closely it will be seen to have a bluish tinge in the sunlight, this bluish tint being approximately complementary to the brownish shadow. If a quantity of smoke be drawn into the mouth from the cigar and retained there for a minute or two and then puffed out into a cloud, it will be seen not

to cast a shadow as pronounced in color as that in the first case. Furthermore, the cloud of smoke will now appear white in the sunlight instead of bluish. While these minute particles of smoke were retained in the moist cavity of the mouth, moisture gathered upon them, for moisture desires small nuclei upon which to condense. This made the individual particles of the cloud much larger in the second case. Now what difference does the size of particles of dust or smoke make? In fact, size appears to make nearly all the difference. Very minute particles scatter the violet, blue, and green rays (technically stated as those rays of shorter wavelengths) more than the yellow, orange, and red rays (those of longer wavelengths). For example, the blue sky owes its color chiefly to this partiality and if there were no particles of dust, smoke, gas molecules, etc., in the sky to be illuminated by the light which is scattered by them and also by sunlight, the sky would be *black* in daytime. At high altitudes the sky does become very dark blue, apparently due to this selective scattering of sunlight by the pure dust-free atmosphere of the upper regions.

Another important phase is the effect of thickness in altering the color. The sun viewed through an amber liquid will appear orange if the depth of the liquid is increased sufficiently, and finally will appear red through a great depth. In a similar manner, the earth's haze alters the sunlight more and more as the density or depth

of the haze increases. This progression of color varies somewhat from time to time but usually is yellow, orange, red. Adding to these colors the color of the bluish and purplish haze, such colors as rose, purple, and salmon pink are produced. The chief details in the production of sunset colors are thus explained, however, a thorough discussion would occupy several chapters. These simple and hurried explanations should help the reader to account for all the sunset colors.

It should not dull the beauty of sunsets to know that the colors are born in the smudge of the earth-haze. In fact, this should exalt the atmospheric haze, for without it the sky would vary little in color from that at noonday. In fact, even the delicate pastel shades of the clouds low down in the sky at noon would disappear and the clouds would appear as boldly against the deep blue as those in the zenith. Without this foreign matter in the atmosphere, twilight would be brief and the glorious afterglow which is sometimes seen for an hour or two after sunset would never appear. This earth-haze which looks like smudge and filthy air from high altitudes extends ordinarily to an elevation of about a mile; sometimes as high as two miles; and on rare occasions into the cirrus-cloud region. Besides this "dust" haze, there appears to be a faint haze of another variety which contributes to the sky brightness but perhaps not much toward the production of sun-

set colors. A discussion of this unimportant haze is too complicated for presentation here.

When the sun is setting blood-red at the earth's surface the aerial observer at an altitude of two or three miles sees the color scheme spread out before him. The lowest clouds are tinged with red, the next higher are of an orange tint; those at his level are a brilliant yellow; and the fibrous cirri two or three miles above him are still bathed in the yellowish white sunlight. Before the direct sunlight reaches the clouds at low altitudes it must pass through great depths of the densest haze. In reaching the higher clouds, the depth of the path of the sun's rays through the haze is considerably less than in the preceding case, furthermore, the density of the haze diminishes somewhat with altitude. From his position three miles above the earth the observer sees the sun practically free from haze and if he were among the cirrus clouds, scarcely any dust haze would be between him and the sun.

From his position the sun is not yet setting, though viewed from the earth it is already touching the horizon. As he watches from his aerial lookout he notes the sun gradually becoming redder as it approaches the horizon which he can barely distinguish owing to the depth of the haze. The lowest clouds gradually lose their reddish tint and as their crests are barely tipped with red their bases are already in deep purplish shadow. The blood-red is now replacing the orange of the

clouds next above the lowest and the orange has moved up to replace the yellow of those at the airman's level. The high cirri are now beginning to assume a stronger tinge of yellow. This succession of color is moving upward as the moments pass.

The earth is now in deep shadow and the low clouds have lost their warmth of color. They are now faintly illuminated with the colder colors of the sky. For the observer at the earth's surface, the sun has set some time ago, and the sky shows a succession of delicate tints from red at the horizon through orange, yellow, and green to blue at the zenith. The aerial observer also sees these but they are more delicate tints to him.

As the moments pass, the observer sees the red sun touch the horizon and the clouds about him are immersed in a flood of red light. Those below him are all in shadow and the fibrous cirrus far above are assuming a salmon pink color. They are bathed in orange light but the blue of the sky showing through their thin filmy bodies mixes with the orange and gives it a pinkish tinge. The watcher down on earth is now in twilight; the sun's glow in the west is rapidly dying; the zenith sky is now "fretted with gold"—the work of the cirrus clouds.

For the watcher above, the sun has now set. All the world below him is in cold deep shadow. Some of the clouds just below him are still bathed in reflected glory and the upper clouds are now

assuming the red tints of the sun which is nearing the horizon. The airman drops from his bright zone toward the deep shadows of earth. Only a few minutes elapse before he straightens out to approach the earth cautiously, for lo! it is almost dark down there. Carefully maneuvering in the dim twilight, several minutes elapse and, when finally he lands, the night lights burst forth. Truly the aerial world so near is yet so far. In a few minutes he comes from the splendor of sunset at polar temperature (nearly zero Fahrenheit) to the suffused darkness of a summer's evening.

The aerial observer of the sunset seeks the coolness of the lookout by the lake, for the hot humid summer atmosphere is stifling after his hour aloft in the arctics. The earthly observer of the sunset is in the lookout where he also watched the sun quench its fires beneath the watery horizon. They compare notes of colors and clouds even to the details of the cloud-forms. The variation in the observations from the two viewpoints is interesting and instructive. An hour elapses during which they have lived over the details of the sunset. It is now dark but a faint pinkish glow is diffused from the zenith. The twilight limit about fifty or a hundred miles above them is still bathed in the sun's radiance. That ethereal something which exists so vanishingly thin in the rarefied atmosphere of the twilight region far above the shallow stratum invaded by mankind, glows

faintly in the darkness. On rare occasions this afterglow is fairly intense, bespeaking variations in the meteorological conditions of this frigid region where the atmospheric density has decreased to almost nothing, marking the approach to that absolute zero of dead space in which other insignificant planets and solar systems exist millions and billions of miles apart. In this infinity of interstellar space worlds are being born and worlds are dying each in its orderly manner ordained by Nature. Occasionally the cosmic dust is disturbed for the briefest moment by the erratic meteoric traveler who has broken the bonds of patient methodic order only to suffer total destruction for his rebellious spirit. A brilliant trailing flash as he enters the earth's atmosphere and he vanishes in the fires of friction, his ashes to mingle eternally with the cosmic dust. Or will they, eons hence, be drawn into a nebulous womb, eventually to be born a part of another star therein to be imprisoned forever and ever?

CHAPTER X

AFTERGLOW

"O, Twilight! Spirit that does render birth
To dim enchantments, melting heaven with earth."
—(Mrs.) Norton.

TWILIGHT may have been meant by the Creator for a period of grace to safeguard His primitive beings from the hazards attending the sudden arrival of darkness. This modulation of day into night may serve many utilitarian purposes, but its beauty and mood impress the intellect and the imagination of those attuned to respond. The quietly fading splendor of the sunset is a benediction at the close of day. Its mood is restful and prepares one for the period of rest to follow. Herein it holds an advantage over sunrise for mankind at dawn has the day's work before him. His mood is not such as to permit him to quietly contemplate the beauties of the dawn and sunrise, for his day's work beckons. However, sunrise, symbolic of the beginning, does fill an office opposed to that of sunset. But both dawn and twilight have their variety. In the open places near the heart of Nature the last lingering

flush of the sky fades to the accompaniment of the music of night-sounds in summer. As twilight fades over the metropolis, civilization's lights twinkle in increasing numbers through the hazy veil. The mood varies with the outlook of the individual, with the season, and with the locality.

The duration of twilight is ordinarily subject to minor variations occasioned by the variable amount of haze and clouds in the atmosphere and by their distribution which depends upon the winds, convection currents, and preceding weather conditions. For these reasons the morning twilight or dawn is generally of shorter duration than evening twilight even at the same place and on the same day. The duration of twilight has been found ordinarily to extend throughout the period of time required by the sun to traverse an arc of about eighteen degrees of vertical depression. During an equinox when the sun is depressed vertically below the earth's horizon, the duration of twilight is ordinarily seventy-two minutes. In those latitudes where, for certain periods of the year, the sun is not depressed as much as eighteen degrees vertically below the horizon throughout the night, darkness is not complete for those periods. Inasmuch as the plane of the sun's apparent path varies in obliquity to the earth's horizon with the latitude, different periods of time elapse for an eighteen-degree vertical depression, hence the duration of twilight varies with latitude.

The sky is often remarkably clear and deep blue after a period of cloudy and rainy weather. The lower atmosphere has been washed, as it were, and the conditions have not been conducive to the maintenance of the haze in the lower atmosphere commonly replenished by the dust and smoke carried upward by the diurnal convection currents. Extensive forest fires, volcanic eruptions, and long periods of dry hot weather when the atmosphere is relatively quiescent for miles above, have been responsible for some of the extraordinary afterglows. Perhaps another condition necessary for the carriage of haze to great heights is a continuous decrease of temperature with altitude,—that is, the existence of no temperature inversions or strata of air warmer than those below them.

Two airmen sit watching the brilliant splendor in the trail of a sunset. The whole sky is aglow with a shimmering rosy light. Their conversation turns toward the glowing heights, for they know that the sun still shines up there. They have sported in the splendor of the setting sun amid the fairyland above them when the earth below was already in deep shadow. These thoughts bring to mind the ever-expanding wonders of flying. The airplane has telescoped distance; it has brought the polar climes of the heights above within an hour's ride; it has brought cloudland almost to man's very door; in fact, it has opened to mankind the beauties, the

wonders, the mysteries of the aerial world above.

With attention turned to the glowing zenith, the airmen realize that from a position two or three miles above they would be watching the sunset. But they have just witnessed the glory of a sunset. Could it be that they might witness two successive sunsets on the same evening? If possible, surely that would be doubling the joy of an evening and would be adding another triumph to the records of flying.

Assuming the conditions of the equinox and a position at the equator, at this time and place the sun's depression below the horizon is perpendicular and, consequently, the duration of twilight is the briefest possible for a given atmospheric condition. At times other than at an equinox the twilight period is of longer duration owing to the fact that the earth's axis is inclined and therefore a longer time elapses per degree of vertical depression of the sun. Simple computations indicate that, under the conditions assumed above, in an aircraft climbing at the rate of about 1000 feet per minute vertically, for the first mile of altitude one is able to see two sunsets in the evening. For example, if one started aloft just as the sun touched the horizon and climbed in such a manner that his resultant vertical velocity was 1000 feet per minute, the sun would begin apparently to rise at first and then gradually to set again. When an elevation of about 5000 feet was reached at this constant resultant vertical velocity, the

sun would appear to be just touching the horizon again. Powerful aircraft are able to do this. In order to make the sun appear stationary at the horizon (at the equator during an equinox) one must reach altitudes of one mile in slightly over five minutes; two miles in slightly over seven minutes; three miles in about nine minutes; four miles in somewhat more than ten minutes. In about thirty-six minutes the sun will just be setting for a position at fifty miles above the earth's surface. Considering the latitudes of the United States at other times than an equinox an aircraft would not need to climb as fast as one thousand feet per minute for the first five minutes to see two very distinct sunsets with a sunrise between them on the same evening.

These considerations turn the attention of the airmen to a further discussion of the afterglow and one of them describes an extraordinary midsummer afterglow and the conditions attending it. The place of observation was in eastern Iowa. For eight successive days not a cloud appeared in the sky and little or no dew was deposited at night. The temperature during the day hovered near 100° Fahrenheit but the air was relatively dry. One had the feeling that there were no appreciable winds for miles above. These appear to be ideal conditions for the dust of the parched earth and the smoke of civilization and perhaps of some forest fires, to be carried upward and upward by convection currents which are not

interrupted as ordinarily at altitudes of a mile or two. At any rate, the brilliance of the sun was very much subdued all day long and appeared pinkish, a brilliant salmon pink afterglow lingering perhaps two or three hours after the sun had set. Various indications pointed to the extension of this glowing haze to many miles vertically upward. About an hour after sunset this glow was extremely brilliant and began to be seamed with straight radial shadows pointing toward the sun already far below the horizon, as though distant clouds beyond the horizon were intercepting the sunlight and casting shadows across the afterglow. But clouds had not been seen during day or night for several days, up to this time, and eventually not for eight days; furthermore, these shadows appeared to be quite similar nightly. The first fact pointed to the unlikelihood of the existence of clouds; the second, if the shadows were really alike each evening, pointed to the necessity of the same forms each evening for casting the shadows. These shadows faded out gradually with the afterglow although the latter lingered when it was too faint to distinguish the former if they were still present.

Clouds could account for these radial shadows which seamed the afterglow but the complete absence of clouds for eight days, during which this phenomenon was noticed the last five evenings, impelled one to seek another solution. What else could cause these shadows in that rolling prairie

which extended uninterrupted to the westward for hundreds of miles? Could these shadows be cast by the Rocky Mountains about eight hundred miles to the westward? This was a daring thought which grew more and more fascinating. The eclipse—a shadow cast sometimes millions of miles through space—is not startling because magnitude is a characteristic of interstellar space. But to witness or even to think of shadows cast by the jagged crests of a range of mountains nearly a thousand miles away on the earth is fascinating. At least it appeared worthy of the application of computations.

Assuming crests of the mountain range to be at an elevation of about 2½ miles above the elevation of the plain eight hundred miles to the eastward, the problem became one of ascertaining how far above the latter locality the shadows would fall if they were just tangent to the proper point of the earth's surface somewhere to the west. In other words, if one stood at this point of tangency and saw the sun just setting over the mountain range to the west and then turned his gaze to the eastward and followed this line extended to the eastward, how far above the given spot in Iowa would this line pass? Computations indicated that this would be slightly more than 60 miles above the earth's surface. Apparently this is within the twilight limit and, inasmuch as the radial shadows were visible at least an hour and quite certainly longer, there is a possibility that on these occa-

sions of extraordinary afterglow there was witnessed the shadows cast by the Rocky Mountains eight hundred miles to the west. It is possible that clouds far below the horizon were responsible for the shadows, but under the conditions the other cause is plausible.

Thus the sky which is empty to most persons is full of interest to the observer. Besides furnishing a vast variety of beauty, of moods, of wonders, and of mysteries, there is something about its contemplation which kindles the imagination. Those who by habit are observing and by the kindness of fate possess sensibilities which feel the mood and charm of Nature are fortunate indeed if their course has led them into the aerial kingdom. How intimate the sky becomes to them! How much greater their world grows! And where their material wings cannot carry them, they go thither on the swift, tireless wings of imagination.

The airmen watch the afterglow fade and grow faint. Knowing the limitations imposed by the rapidly decreasing density of the atmosphere with altitude, they dare not hope ever to visit that twilight limit up above. But as the last flush of the afterglow disappears and they stroll homeward, they satiate that longing with a promise to see two sunsets tomorrow evening.

CHAPTER XI

A POLAR CLIMB

"The chasm of sky above my head
Is Heaven's profoundest azure. No domain
For fickle, short-lived clouds, to occupy,
Or to pass through;—but rather an abyss
In which the everlasting stars abide,
And where soft gloom, and boundless depth, might tempt
The curious eye to look for them by day."

—WORDSWORTH.

IT is a calm, cloudless day in late summer and the sky is of that deep clear trembling blue which sometimes follows a rainy spell. It is one of those rare days for exploring the upper regions and two airmen succumb to the call of the blue heights. They have often discussed a climb to the ceiling—the highest altitude attainable by their craft—and this is the ideal day for such a flight. This will not be an altitude record, but they will ascend to the ceiling for their craft, which will be more than four miles above them. They examine the oxygen tanks and helmets, for in that rarefied atmosphere above they must supply their own oxygen if they would not run the risks of going to

sleep for lack of sufficient oxygen. They don their arctic clothes, for they are going where the temperature will be below zero Fahrenheit. Their preparations are based upon experience and upon a knowledge of many general facts of the atmosphere.

The atmosphere at the earth's surface consists principally of nitrogen and oxygen, the former comprising about 78 per cent of a given volume and the latter about 21 per cent. The remaining one per cent is made up chiefly of argon, carbon dioxide, hydrogen, neon, and helium, ranking in volumetric proportion in the order given. Owing to the continual stirring of the atmosphere by convection currents, the volumetric proportions of the different gases are practically the same up to about seven miles. Above this altitude the temperature changes only slightly with elevation and, therefore, vertical convection is absent. In this region the gases are distributed according to their relative weights.

The content of water-vapor in the lower atmosphere varies considerably, but decreases with altitude, so that the absolute humidity is practically zero at altitudes above seven miles.

The temperature decreases rapidly with elevation but varies for different places and seasons. There is less difference between the summer and winter temperatures of high altitudes than of low ones, and as would be surmised, at very high altitudes the temperature is not affected by the sea-

sonal changes at the earth's surface. In fact, above seven miles in the latitudes of the United States, the temperature changes very slightly with elevation in the region which has been explored by means of small balloons equipped with instruments. This region is called the "stratosphere" and its temperature averages about 65° Fahrenheit below zero. The altitude of the lower surface of the stratosphere at the equator is nearly ten miles and its average temperature is about 95° below zero. The temperatures of the lower levels vary considerably but in the summertime in the temperate zones freezing temperatures are commonly encountered at two miles or slightly above, and zero Fahrenheit is encountered at elevations of about four miles. Although the rate of decrease of temperature with altitude varies considerably with elevation, season, and locality, a very rough approximation is a decrease of about 4° Fahrenheit for each 1000 feet above the first half mile. When the temperature at the earth's surface is high, the rate of decrease of temperature with altitude is usually higher for the first mile or two than when the surface temperature is low.

The atmospheric pressure decreases with altitude as is well known by experiences on earth. At an altitude of three miles the pressure is about one-half the value at sea-level; at seven miles it is about one-fourth; and at twenty miles it has decreased to about one-hundredth the value at sea-level.

The winds which play such a part in whipping the clouds into various shapes and patterns, thus revealing themselves, increase in general with altitude, although their velocities in the cloud region vary greatly from day to day. In the north temperate zone the winds in the upper cloud region are more rapid in winter than in summer, but in the intermediate and lower cloud regions they apparently are in general somewhat slower in winter than in summer. Approximate average velocities of winds at Washington, D. C., for various altitudes are: 25 miles per hour at an elevation of one mile; 35 miles per hour at two miles; 40 miles per hour at three miles; 55 miles per hour at five miles; 65 miles per hour at six miles. In this country the maximum velocities of westerly winds in the upper cloud region attain over 200 miles per hour and a velocity of 175 miles per hour is not rare. The eastward movements of storm-centers or cyclonic areas in the north temperate zone are generally at the rate of twenty to thirty miles per hour and in the direction of the higher clouds or of the atmosphere at altitudes of four to six miles.

These are some of the more important aspects of atmospheric conditions with which the well-equipped airman is familiar. Meteorology will become a science of more general interest as mankind becomes absorbed in flying, and in return for the aid that meteorology has given to aviation in

its infancy, aviation will contribute much to the knowledge of this science.

After careful attention to details the airmen are ready to ascend. Forethought is of great importance to the aerial traveler and doubtless many airmen have come to grief from a lack of it. The temperature is nearly 100° Fahrenheit as the airmen start for the aerial arctics. It is difficult to conceive zero temperatures awaiting their arrival in an hour or so. If their craft were of the most powerful type they would reach an arctic zone in an hour or two where the temperature is about sixty degrees below zero. They take to the air and begin their climb into the clear, deep blue sky.

Soon an elevation of one mile is reached and their radius of vision has expanded to about ninety miles. Rivers, lakes, and striking earth areas fifty miles away may be seen easily and the horizon of the ocean ninety miles distant is clearly visible against the blue-white horizon sky.

They continue to climb and when an elevation of two miles is reached their range of vision is about one hundred and thirty miles. They begin to appreciate the comfort of arctic clothing, for the mercury of the thermometer is hovering near the freezing point. The view is one of those rare ones of extremely high visibility, but despite the clarity of the atmosphere some haze is present over the land, for distance alone is not responsible for the blurring of earth details near the horizon.

As they continue to ascend the thermometer

steadily falls and when they reach an altitude of three miles it registers ten degrees above zero. Their range of vision has extended to about one hundred and fifty-five miles. Although the day is very clear there is present a slight haze and now a three-mile depth of this sunlit haze has spread a thin white veil over the earth. All this time the blue sky is becoming darker, for the white veil below has been taken from the sky. Distant details of the earth's surface appear clearer than at low altitudes because the obliquity of vision has decreased. Yonder cape sixty miles distant appears but a short distance. The chief details of its irregular coastline are plainly visible. The atmospheric pressure has decreased to about one-half its value at the earth's surface, but they do not notice the scarcity of oxygen because they are not physically active. In the exertion of mountain climbing the tourist becomes conscious of the rarity of the atmosphere and accordingly decreases his exertions. But no such compelling warning safeguards the airman. The rarity of oxygen may merely make him languid or sleepy and the possible results are easy to contemplate.

As the airmen continue their ascent experience tells them that soon it would be wise to don the oxygen helmets although by no means is it essential at this altitude. The temperature is steadily falling and the cold wind striking their faces as they peer over the edge of the cockpit pierces their flesh. The slip-stream from the propeller directly

ahead of them, added to the actual air-speed of the craft, makes a gale of more than one hundred miles an hour. As they near their "ceiling" their rate of climb decreases, owing to the decreased density of the air.

They reach an altitude of four miles and the thermometer registers below zero—colder than the coldest days of winter at their locality. Their range of vision has now expanded to one hundred and eighty miles. The horizon of the ocean is plainly visible at that distance, a different hue than that of the horizon sky. The courses of several rivers may be followed for one hundred miles toward their sources in the indistinguishable mountain range which is blended with the distant horizon. These rivers empty into the bay many miles apart but both their widened mouths are plainly visible. A vast area of 100,000 square miles (sixty-four million acres) of the earth's surface lies within the circle of the horizon. Iowa could lie completely in this circle and still cover only about one-half the area. An island like Porto Rico (3435 square miles) would cover only a small portion of the area below them and the shimmering sea which bounds it upon all sides would be plainly visible at an average distance of about forty miles. The combined land area of the British Isles is only slightly larger than the circle bounded by their horizon at this altitude. Nearly all the states of the United States could lie individually within this circle and several of the

smaller states could be grouped within it at one time. The vast range of vision is one of the wonders and inspirations of cloudland. When one has had opportunities to see in a single view many miles of filigreed coast-line or the intricate pattern of a river and its minor tributaries, he loses respect for the accuracy of maps. Yonder cape is not a rounded point; its coastline is a fringe of delicate lacework of earth and water. Aerial photography will aid the map-maker of the future.

The vastness of the field of vision leads the imagination to demand more computations. (The horizontal distance to the horizon is approximately equal to ninety times the square root of the altitude in miles. At an altitude of seven miles the horizontal distance to the horizon is two hundred and forty miles. These are altitudes attainable by the aerial traveler, but from those forbidden heights above these, there must be wonderful views. What a price would one pay for a few moments at an altitude of two hundred miles above the central part of the United States with a perfectly clear atmosphere beneath him, whence he might see the Atlantic Ocean faintly shimmering under the rising moon and the Pacific Ocean glowing in the rays of the setting sun. And while on the wings of imagination, one might rise to an altitude of 1500 miles whence his horizon circle would nearly equal a great circle of the earth. His line of vision when gazing toward the edge of the distant earth would make an angle of about

forty-five degrees with the vertical. It may aid visualization of such an imaginary view of the earth to place the eyes three feet vertically above a horizontal circle six feet in diameter. This circle subtends approximately the same solid angle at the eyes that the earth would when the eyes were 1500 miles above it. Imagine a map of the Western Hemisphere drawn on this circle and that as the eyes rove over it and leave its edge, they look into the void of space. At any time except near noon the observer at an elevation of 1500 miles would see night and day simultaneously on the earth.

If atmospheric conditions permitted his gaze to penetrate toward that distant horizon of the earth he might see the white ice-cap surrounding the north pole, and the continent of North America, a small area below him, dimmed and blued by the depths of space and blended by distance into velvety bluish gray, buff, and bluish green areas, depending upon the distribution of seasons, and touched here and there by the white of clouds. Night and day would be visible simultaneously; perhaps day over the Atlantic, dawn over the continent and moonlight over the Pacific. Perhaps the eye would follow down this continent noting the constriction at its southern end beyond which expands another continent to the south. In the dim distance of the far south a white area might be a cloud-mass or the edge of the Antarctic polar ice-cap. Surely the wonders of man's new world

—cloudland—kindle the imagination and make Jules Verne plausible.

In the foregoing views from unattainable heights, a perfectly clear atmosphere is assumed. The earth would still be veiled in the blue of clear air. Under the conditions as they actually are, the earth haze would add a white luminous veil so that the details of the earth would be very much befogged.

While the airmen enjoy the grandeur of the extensive views, the craft mounts higher, but slower and slower is its climb. It is approaching its ceiling. The winds are very strong but the craft bravely meets them, for it is headed into the wind most of the time. If the speed of the airplane in still air is one hundred miles per hour, it will just maintain its position in space if headed directly into a wind of the same velocity. As the airmen climbed they watched their drift and kept the craft approximately vertically about a chosen landmark. In doing so, they are conscious of the approximate direction and velocity of the wind at various elevations.

The temperature is steadily falling and the dark blue sky apparently emphasizes the cold. The untempered sun breaking through the dark sky casts harsh dark shadows like those under a lone street lamp at night. The sky which is ordinarily bright, chiefly by virtue of the illuminated dust or haze, is now so free from such particles that it appears like a transparent blue-black. The brighter area

of sky near the sun, as is commonly noted when viewed from the earth, is no longer conspicuous. The faint brightness of the canopy above is that pure blue of space, the source of which is still in doubt. Through this darkness amid the piercing cold of the arctic temperature, the sun's rays appear to come without their usual heat. The crescent of the moon, which seen from the earth is barely brighter than the sky, now shines more brightly amid its dark blue surroundings. Perhaps, if the airmen look carefully, they will distinguish some of the more brilliant stars because they are always awaiting behind the haze-veil of the daytime sky.

The airmen are now in the region of mackerel skies. They are in the realm of perpetual cold. Here the filmy clouds consist always of floating ice. This indeed is a polar clime and still only a short distance from the earth and summer weather. The distance is about one hour up and ten minutes down.

The airmen realize that the craft is very slowly ascending and that their ceiling lies somewhere between four and five miles. Higher altitudes offer more experiences but, after all, what is a mile or two or three higher when space extends to infinity! Man's invasion of the air has opened the wonders of a new world to him. The scanty film of space a few miles in thickness of which he is now master is a spacious wonderland when compared only with earthly dimensions. Man has

personally ascended in this sea of space to an altitude of about eight miles above the level of the oceans, and inasmuch as clouds do not extend much higher, he is in reality master of cloudland. He has flown kites to altitudes of about five miles. In the study of meteorology he has sent up balloons with recording apparatus to about twenty-two miles. Small balloons without apparatus have attained elevations of about twenty-five miles. At these highest altitudes from which mankind has obtained data directly, the atmospheric pressure and density are less than one per cent of their values at sea-level. Rare as it may be at the highest level explored, there are many reasons for suspecting that atmosphere still exists, though extremely rarefied, at altitudes up to one hundred miles at least.

Up in those regions where the last vestiges of the earth's atmosphere are dying away and that infinitude of frigid emptiness begins, there are other phenomena to interest mankind. The twilight limit is somewhere below one hundred miles, and the region above thirty miles and below one hundred thirty miles is that where the "shooting stars" stage their pyrotechnic displays. Surmounting these, sometimes at altitudes as high as five hundred miles, are the mighty auroral arcs. These restless shifting curtains, streaks, bands, and arcs are the electrical effects of the heavenly stage. Thus it is seen that the wonders of space never cease. Cloudland is full of interest, but as

one mounts higher and higher on the wings of the imagination, wonders of greater magnitude unfold without end. The aurora is the last visible phenomenon associated with the earth, but farther and farther into the infinitude of space, events of tremendous magnitude are taking place.

Thoughts of these wonders above them occupy the minds of the airmen as their craft battles against wind and gravity. For some time the altimeter has appeared stationary; evidently the faithful craft has reached the limit of its powers. The actual altitude is of no great interest here, but it is between four and five miles. The temperature is fifteen degrees below zero Fahrenheit.

One of the airmen looks toward the other with a significant sign and apparently there is agreement. The motor is throttled and the craft dips suddenly downward. For a moment the airmen have the feeling that the craft is leaving them. Downward they glide at a steep angle; the craft tilts to a steep bank; and with controls set in just the correct position the craft describes a helix of small diameter and large pitch. This is misnamed a close or tight spiral. The thousands of feet are clipped off rapidly as they descend steeply and dizzily as they "spiral." The plane of the earth wobbles as though it were on a stormy sea. For minutes this descent continues, then to relieve the monotony and seemingly to "unwind" their somewhat confused vision, the controls are thrown over to another position and the "spiral" is reversed.

The wobbly whirl goes on for minutes which would seem an eternity to one who is not a good sailor. The close "spiral" is chosen as a fast and safe mode of descent because the course of the path is such as to insure against the attainment of unsafe velocity. The craft does not tend to accelerate as it surely does in a nose-dive, but it attains a constant and safe speed of descent determined by the angle of the craft and consequent air-resistance.

Down and down they continue their descent until suddenly they become conscious of a much warmer temperature. They are only a few thousand feet from the earth. Their goggles are steamed over, their faces feel damp, and everything their hands touch seems covered with moisture. The cold temperature attained by these objects at the high altitudes accounts for the condensation of water-vapor in the more humid lower atmosphere. Shortly they glide to rest safely on the ground. They feel uncomfortable in the heat of midsummer and it already seems as if they had dreamed that their thermometer registered zero ten minutes ago. This polar climb has not been filled with the beauties of some other flights but it has supplied some wonderful views. It has awakened the imagination and has pointed the way to new avenues of thought. In fact, it was a trip worth including in the itinerary of the sojourner in cloudland.

CHAPTER XII

CLOUD CAPERS

"Heavenly clouds who supply us with thought and argument and intelligence and humbug and circumlocution, and ability to hoax, and comprehension."

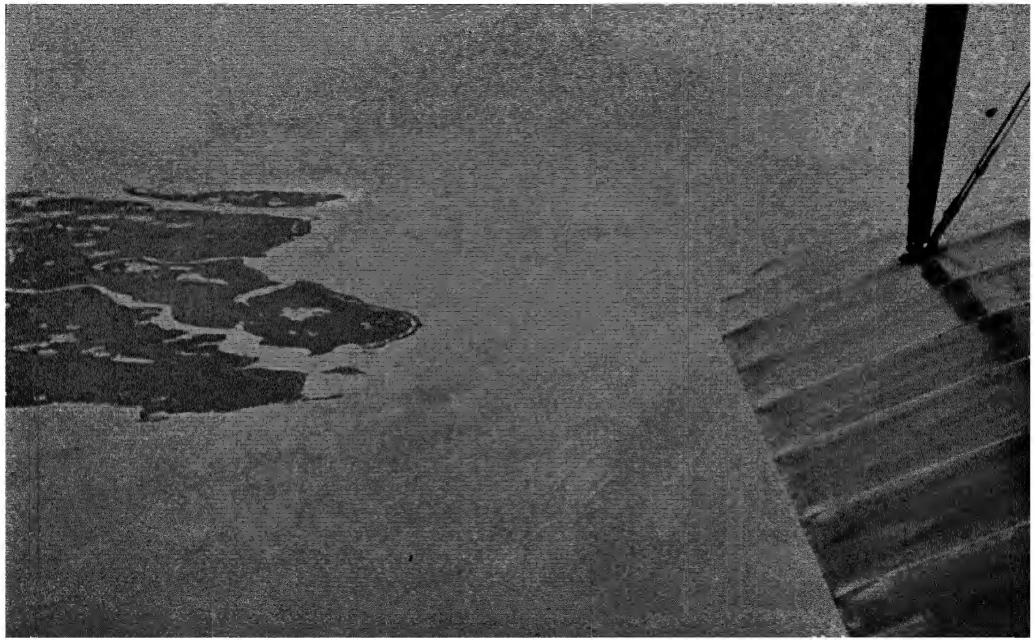
—ARISTOPHANES.

THE antics of clouds and their ever-changing forms have been touched upon throughout this little volume but it is hoped a few random notes will not be unwelcome. Their sudden appearance and disappearance so appropriate to their spirit-like texture and to their invisible world, their restlessness, their endless variety, make it easy for one to become deeply absorbed in this aspect of the heavens. The aerial traveler need not be alone when clouds are in the sky. A scene need not become monotonous if one but looks to the moving clouds, and if one does not like the scenery of the moment he needs only to await the scenery of another moment. Amid the day's work an open window and a patch of sky will afford an escape from the routine grind. Everywhere and at all times except on those rare cloudless days the clouds are per-

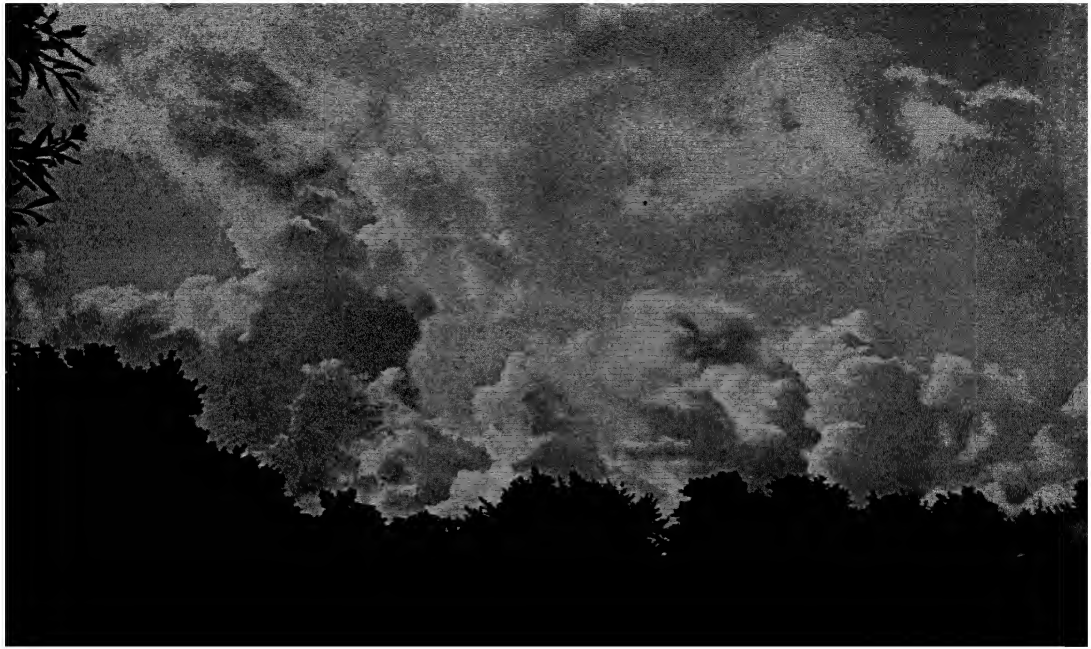
forming for observant beings. Their manifold forms and modifications arouse the fancies and impress one with the conviction that they are trying to tell mankind much that he does not know. To describe these endless capers would be a task as long as eternity, but to attempt to give an idea of these antics is a short and pleasant recreation. These few paragraphs, then, are merely representative of this aspect of clouds. They are garnered chiefly from recent casual observations of the sky which are fresh in memory.

It is a clear summer morning and dew sparkles in the grass. At first not a cloud appears in the sky but in an hour or so as the sun evaporates the dew, thin clouds appear. The dew now floats in the sky whence it came during the night. The ascending currents have carried this evaporated dew to regions where it becomes sufficiently cooled, chiefly by expansion, to lower the temperature of the air below its dewpoint and, therefore, clouds are formed. At first these are thin but rapidly they become larger. If one lingers over his work for a time he may be surprised to note as he glances skyward in an hour or so, that a vast flock of fair-weather cloudland has come into being. Eyes cannot see the whole process of evolution but the mind may see what they do not.

Yesterday at noon the crests of the fair-weather cumulus clouds were leaning forward as though they were anxiously straining to move faster than the wind. Today their crests are leaning back-



A HUGE PORTION OF A STATE PROJECTING INTO THE SEA



A BATTLE OF WINDS AND CLOUDS

ward as though they are reluctant to go whither the winds commanded. Their attitude of yesterday is perhaps the more common of the two. Cumulus clouds are formed by vertical convection currents, the fair-weather type being formed chiefly by mild differences in temperature between adjacent bodies of air. As the heated air rises, some of the moisture condenses and condensation continues as the air ascends. Hence the clouds have considerable depth and appear like heaps. If the wind at the level of their crests is of sufficiently higher velocity than that of the stratum of their bases, the crests will strain forward. If of sufficiently lower velocity, the crests will lean reluctantly backward. If the difference in the two velocities is sufficient, the clouds may be torn into fragments; hence, this is one source of the fracto-cumuli which often go racing by. Thus, simple observations may lead from one to another and thereby uncover much pertaining to the air. It is interesting to picture in the mind's eye the invisible currents and their influence upon one another.

Toward the close of the day the upward convection currents grow weaker and weaker with the result that the cumulus clouds become flattened or even like stratus. This is the reason for the lower stratified clouds of last evening's sunset.

Sometimes a sudden weakening of the upward current which supports the cumulus cloud in its beautiful rock-like shape, results in a striking

formation variously called globo-cumulus, pocky cloud, festooned cloud, and mammato-cumulus, the last name being official. The lower side of the cloud bears an appearance something like flat globules of water clinging to the lower side of a horizontal surface such as a ceiling of a room. These have been called "rain-balls" because their rare occurrence is generally in connection with a thunderstorm. Suppose very cold air or even snow drifted out of the top of a thunderstorm over a thin stratus cloud. This cloud would be cooled and would begin to sag in spots and there must be rises interspersed between the sags. Thus the shapes of these clouds may be accounted for. When these festoons appear just before sunset as they did recently, thus receiving reddish light from underneath, their beauty can hardly be surpassed in cloudland.

A few days ago the cumulus clouds floating over the water were small and rather flat. The morning was hot and the cumulus clouds over the land were rearing strongly upward. As the clouds drifted from over the water and reached a position vertically above the shore, they were torn violently and rapidly upward in a variety of shapes, and all were tattered as the result of the rough treatment. This performance went on for hours and clearly demonstrated to the observer the superior strength of the upward currents over the land, which, of course, was hotter than the water. These capers of the clouds were exceedingly fas-

cinating both from the viewpoint of beauty and technical interest and furnished an endless variety of rapidly changing forms.

Cumulus clouds often may seem to be stationary for hours despite the gentle breeze which may be blowing and a question arises as to how they maintain their position against a breeze. The ascending convection currents, once formed, seem to maintain their position with respect to the earth to some extent against the surface wind. The ascending air with its load of water-vapor is cooled chiefly by expansion as it reaches the higher levels and some of the moisture condenses and replenishes the cloud which is evaporating on its crest and on its leeward side. In other words, the cloud is being formed as rapidly as it is drifting in the wind and being evaporated.

Another example of stationary cloud is found in the clouds of the mountain top. The moist air of the lowlands is driven up the mountain side and condensed in this cooler and rarefied region. The cloud thus formed is constantly moving with the wind and evaporating, but is also continuously replenished. Depending upon the velocity of the wind and upon other factors, the cloud may cover the crest like a mantle; it may hover over it like a sun-shade; it may maintain a position to the leeward; or it may wave from the peak like a banner.

A similar case was witnessed on many aerial trips over a vast swamp containing several hun-

dred square miles of low waste land in the center of which was a small lake two or three miles in diameter. A low fringe of clouds often hovered over one side of the lake when the rest of the sky and landscape was cloudless. These clouds were so often found that their occasional absence became a disappointment.

Mariners have often "sighted" an island in the midst of an ocean long before it appeared on the horizon by the lone cumulus cloud which hung above the horizon. Such a cloud-cap floating above an island is a common observation. Despite the wind that is blowing it maintains its position even though it is also drifting with the wind, for as fast as it drifts away and is evaporated on one side it is being replenished by the moist air ascending from below by virtue of its higher temperature and consequent lesser density than the surrounding air.

Cumulus clouds are most easily observed owing to their size and proximity to the earth, although these features are disadvantages when such clouds are overhead. In this position their gray flat lower surfaces are uninteresting and conceal their beautiful forms. The rearing cumulus which stations itself over toward the horizon, but not too far away, is conferring a favor upon mankind which is not generally enough appreciated. Sometimes the entire evolution of a thunderstorm may be seen and when the opportunity is thus advantageously presented it is deplorable that

mankind does not observe these most majestic of all aerial sculptures.

Cumulus clouds of higher altitudes, the alto-cumuli, are smaller than the cumuli proper but larger than the cirro-cumuli of still higher regions. These are generally globular but assume a variety of forms too numerous to describe. They are usually in flocks, shepherded by the winds into patterns and long columns. Their formations are confusing to the earthly observer owing to the illusions of perspective, but the aerial traveler becomes very familiar with their forms and levels.

On a quiet day the upward convection currents are robbed of some of their moisture and the cumuli are formed. The air may continue to ascend and on reaching a stratum of air of sufficiently low temperature and high humidity, some more moisture may be condensed. This cloud which would not be dense is left behind and at a higher altitude the process may be repeated. In this manner some of the clouds of various levels may be accounted for, especially in fair weather.

On nearly every day when several varieties of clouds are in the sky, one may watch a group speeding confidently past only to vanish in thirsty air. Thus a clear area beyond may be continuously fed with clouds from the supply to the windward.

One morning a few days ago the entire heavens were overcast by a beautiful pattern of billowed cloud, symmetrical in two directions approxi-

mately at right angles. If one happened to be a close observer of wind-patterns on water or of the effect of a cross-current upon a drifting layer of smoke he might be able to visualize the mechanism which formed those beautiful billows. This effect may be seen in the smoke-stream from a steamer which is traveling at an angle to the direction of the wind. The airman at the level of the billowed cloud sees huge waves sometimes hundreds of feet vertically between the levels of crest and trough respectively. He notes as he rises through this region that one current of air is overrunning another current. The interaction of these form the billows as explained elsewhere. These effects take place at all levels,—from fog to high cirrus levels,—hence the vast variety of patterns of the high clouds.

The stratus clouds are not beautiful but they add at least color to the sky as they lie now in bright sunlight and again in blue shadow. They are found at all levels. Sometimes they are broken or of varying density and are responsible for some of the delights of a quiet moonlit night. One may see them form if closely observant. They are often formed by a layer of cold air underrunning or sliding, as it were, underneath a humid layer. Inasmuch as this may take place at any altitude, the stratus clouds may be formed at any level. They predominate, however, at certain levels as indicated in other chapters. When the

air is fairly still it is easy to note their appearance and growth.

A few evenings ago the sky was perfectly clear and the moon was already high. Suddenly, at least it seemed so, a thin layer of cloud appeared which rapidly grew to a fair density. No drift could be detected and inasmuch as the air seemed still even at the altitude of this cloud-sheet, which was probably a half mile, the cloud seemed to have been formed in its position. This could have been the result of cooling in place by loss of heat after the sun had set, or by other undisturbing means.

A few days ago a vast array of fair-weather cumulus appeared in the sky about the middle of the morning. They were lazily floating and of the strictly heaped formation, though not large. The breeze gradually grew to a stiff wind and the temperature lowered. In the course of an hour those fluffy cumuli had flattened to forms resembling ragged cakes of ice. The area over a large body of water was perfectly clear, but down the sky over the land these flattened cumuli marched in disorder. Huge mountains of clouds to the windward disappeared and these small cumuli faded in two hours, leaving a perfect, cloudless sky. The majestic disorder of these clouds, their rapid change of form, and their gradual disappearance are inadequately described in words, but it was a sky worthy of occasional glances at least. Surely the Creator erred in supplying such attractions

so often. Occasional appearances doubtless would result in more appreciation of the marvels of cloudland.

Late in the afternoon yesterday the heavens contained a large variety of clouds at several levels even to the high cirri. It seemed as if there were a general clean-up going on. It was one of those conditions that the observer of the sky and the appreciative air-traveler longs for, not only for the variety of interest in the clouds themselves, but their multi-forms and various levels late in the day give assurance of a riotous sunset. The most gorgeous sunsets depend for their effects upon clouds at several levels. True to precedent, the sunset an hour or two later was of the best that autumn can produce. Incidentally, it seems that autumn is the season of wonderful sunsets. The pastel tints of this season were lavished with masterful genius upon the clouds of many forms at various levels, from low bits of flattened cumuli to the highest cirri. These clouds as they alternated in and out of the sunlight, first in cold-tinted shadow and then in warm-tinted sunlight, conspired to make a spectacle of riotous splendor. When clouds are dispersed in this manner in late afternoon, one learns to look for a sunset which is well worth an unobstructed view.

Among the most fascinating clouds are the towering cumulo-nimbus or thunderheads. Their vigorous turbulence indicates powerful upward currents. As these rear higher and higher their

crests become more and more interesting. During midsummer one of these towering giants of cloudland took up a position about ten miles away and gradually extended itself until its crest reached an altitude of several miles. During this rise, a thin cloud formed above its head and as the crest rose this thin veil appeared to drape over it. As the head rose higher it left the thin cirrus-like cloud behind. Seen from the heights, this cloud resembles a thin fog obscuring the crest for a time until the latter forged upward through it. While watching this huge thunderhead from an altitude two miles above the lower ordinary cumuli, the intricate details were easily analyzed without the confusion attending the view from the earth, owing to perspective. However, the illusions of perspective are not as confusing for towering cumuli when they are at a proper distance as for the thinner clouds of extreme heights. Later as viewed from the ground, several fragments seemed to break loose from the crest of the thunderhead and went drifting rapidly away. Casual observation does not reveal the rapid changes which take place in the turbulent crests of these towering cumuli. If one needs to be convinced let him take a number of photographs at intervals of two or three minutes.

Although all clouds afford a variety of interest, the cumuli doubtless furnish the most attractive individual antics. They are large and often close enough to be in the same air-current which

brushes the earth's surface. Their origin is clearly established and all their details are easily understood. For these reasons they afford excellent objectives for the observer of cloud antics. It appears hopeless to invade the field of high clouds in this chapter for, although their rapidly changing forms are exceedingly interesting, relatively few would care to read the more involved explanations which, owing to the less general acquaintance with these clouds, are not easily visualized from verbal descriptions. The purpose of the chapter is attained, however, if by a few commonplace examples, it has given the reader a glimpse of another viewpoint or attitude toward the clouds.

Occasionally tufts or veils are to be seen hanging from compact masses of high clouds. Sometimes these are showers of rain or snow taking place in the heights of cloudland. They may be evaporated by thirsty air before falling far. At other times they may be merely streamers pulled out by the winds. They may actually be hanging downward or they may merely appear to be pendent due to an illusion of perspective.

The terms "canopy" and "dome" as applied to the sky do not arise from pure fancy. As one observes the heavens he becomes conscious of an illusion of the sky which makes it appear like a dome. Whether this illusion is due to a suggestion of a dome shape by the sky itself or arises from our own inner reasoning, the author is unable to de-

termine; however, it is a recognized illusion. In fact, experiments have been made to determine the apparent shape of the sky dome as it appears to groups of observers. The results indicate that most persons would consider it a flattened dome, that is, not a true hemisphere.

One cannot observe the clouds for entertainment without thinking occasionally of their useful function. They visibly represent the moisture in the vast sea of air above the earth. As the airman travels through the transparent atmosphere he is rarely conscious that he is also passing through water-vapor. Ofttimes in this transparent air there is more moisture in a given volume than in the same volume of clouds, but this water-vapor before it falls to earth must pass through the cloud stage. Hence, clouds are the vehicles which sprinkle the earth with rain. A surprise awaits those who would compute the weight of water which yearly is evaporated from the earth and returned to it again by way of the clouds. The total weight of water spread over an acre of ground to the depth of one inch is about one hundred tons. In regions where the yearly rainfall is fifty inches, the water delivered by the clouds per year upon an acre of the earth's surface is approximately five thousand tons. The total tonnage of a fifty-inch rainfall over a square mile is more than three million tons. The total tonnage of water deposited yearly by the clouds upon the state of Iowa is approximately one hundred fifty

billion tons. The tonnage for the United States is represented by an incomprehensible number and for the entire earth proportionately larger. This gives another glimpse of the magnitude of the scale upon which Nature operates. It helps one to comprehend the existence of the mightiest storm which is really a pigmy in Nature's scale. It kindles one's imagination regarding the greatness of cloudland and the immensity of the meteorological scheme which is carried out in this region. And after all, the clouds and winds are law-abiding and do their parts as assigned to them by those conditions which rule them.

CHAPTER XIII

A NIGHT FLIGHT

"Now black and deep the Night begins to fall,
A shade immense! Sunk in the quenching Gloom
Magnificent and vast, are heaven and earth."

—THOMSON.

THE last blush of the fading sunset lingers in the sky. Already at their outposts the sentinel stars have set their watch in the heavens to be reinforced as darkness deepens. Two airmen sit patiently contemplating the approach of night, their aircraft dimly outlined on the field before them. One might readily imagine that it, too, were waiting. Night flying has not the variety to make it as appealing as flying by day, but the mood of night in cloudland is so powerful that an occasional flight by night is worth while. Over near the horizon lightning flashes reveal momentarily a low-lying range of cloud-mountains, a bluish white with steely blue shadows, so cold compared with the glowing crests by day. As darkness spreads its pall, myriads of stars stud the sky overhead.

The field lights burst forth and reveal the two

airmen boarding their craft. The engine is started and allowed to warm up. The roar gradually increases and finally dies down, almost a sure sign that the blocks are being removed and the craft is to begin its journey aloft. A spurt or two and the craft speeds down the field soon to be lost in darkness except for its tiny lights. For the airmen the illuminated field rapidly dwindles to a dimly lighted patch. At an elevation of a thousand feet the earth is but the faintest ghost of itself. The dull earth of daytime is now weirdly enchanting. As the airmen mount higher and higher nothing is definitely visible below except civilization's lights. They have no horizon to aid them in keeping an even keel, but the lights in the distance are far enough away to serve the purpose of a horizon until they are above the haze.

A feeling of loneliness creeps over them only to be suppressed again by the grandeur of the starry night. The sky is full of company, distant though the stars may be. Space is not the lonely solitude that it is by day when only the sun inhabits the blue. The haze which cannot be seen is effective, however, for the stars diminish in number toward the place where the horizon should be. Far ahead is the subdued glow of a distant city. Below a tiny beam of light marks a train guided through the darkness by its path of steel. In the distance the lightning still continues to illuminate spasmodically the vaporous crags of the cloud-mountains, revealing the rendezvous of Jove and his

cohorts. The airmen turn the craft toward that flashing range and continue to mount higher. As the earth lights grow dimmer, the stars grow brighter. They are leaving the earth's haze behind them.

An altitude of five thousand feet is reached and the black sky is studded with brilliant stars over its entire hemisphere. The horizon is indicated by an invisible boundary of the starry heavens. Above the earth haze the brilliance of the numberless stars is unimpaired. There is grandeur, magnificence, and infinitude in the apparent lack of order in their arrangement. They lie in such confusion that the inability to estimate their number leaves one with an impression of infinity. Some one has called the sky, twilight's curtain. Imagination suggests that these stars are pinholes in the curtain and that Day is concealed behind it.

As the aircraft mounts higher and approaches the distant storm, indescribable feelings of awe overtake the airmen. The storm with all its majestic turbulent clouds is an awesome sight in the daytime when its lightning flashes are feeble. But the mood of night adds to the mystery, the magnitude, the intensity, the effectiveness of many events, especially storms. To the airmen all the powers of the daytime storm are multiplied by the strangeness and possible dangers of flying at night. But men who have felt the thrills of cloudland and who have known the inspirations of fly-

ing could not turn away from even the overwhelming awesomeness of this brilliant electrical display, as,

> "Far along
> From peak to peak the rattling crags among
> Leaps the live thunder."
>
> —Byron.

As they approach closer they recognize, during the flashes, the same characteristics of a thunderstorm by day. All around, above and below, is darkness pierced only by faint points of light compared with the brilliance of the flashes which illuminate the clouds for miles beyond. With each flash they and their craft are brilliantly illuminated. They see part of the course and almost the source of some of the flashes. Now a crooked lance of brilliant steel-blue light darts from cloud to cloud. Another shaft starts from near a peak and is visible for only a short distance through an opening in the clouds. The light from each lance is reflected here and there among the crags in the abysmal depths producing a display whose magnitude, whose awesomeness, whose magnificence, words cannot describe.

In "the dead vast and middle of the night," alone in space nearly ten thousand feet above the earth, they witness a splendid spectacle. Their friends at home in the distance who see only the flashes faintly in the distant sky perhaps casually mention "heat lightning." This *is* "heat light-

ning," that is, lightning of a storm out of sight near or below the horizon. The airmen think of those below upon whom the storm is bestowing the blessing of rain but demanding its pay in the devilish pleasure it probably gains from the terror instilled by those brilliant lightning flashes and accompanying roars of thunder.

The two airmen high above those scowling, flashing, thundering clouds are not cringing in terror. They strain forward in their seats wholly absorbed by the magnificent splendor. Awe is the nearest approach to fear among the gamut of emotions which they experience. They are out of reach of the storm and this feeling of supremacy does not escape them. They are taking chances, for the few risks of flying by day are multiplied at night. But they are unafraid, for their philosophy has long ago put them at ease. They have lived long in their hours in cloudland. To them living is measured in terms of intensity and the intensity of living during the past hour would cover many days of every-day living if spread out to ordinary thinness.

During this time they have soared back and forth viewing the flashing vaporous range from various angles, but always out of reach of the storm. Such storms by night do not usually extend to such high altitudes as the exceptional thunderhead of the daytime storm. They leave this spectacle with the greatest reluctance, for it fascinates them as the abysmal canyon draws the fearsome

tourist to its edge. They turn back toward home guided by the stars although the luminous compass before them would show the way. However, the stars are more convenient; that "glorious host of light" is the infallible guide of the traveler in uncharted places. Above them the constellations describe their heavenly paths in definite and established order around Polaris. This North star, toward which the axis of the earth very nearly points, appears fixed, hence, it is the pivot around which the constellations swing.

As the airmen soar homeward they note a beam of light swinging around the space below them. They follow its bright patch from the earth to a level far below them above which it appears to weaken. Suddenly they are blinded by a powerful light, but only momentarily. It is a searchlight in quest of them, for the crew has heard the purr of their motor. Their high speed took them out of the beam before the crew of the searchlight realized that the tiny speck was the object of their search. There is another blinding flash as the beam is turned full upon them again. This time they are held in the beam. The searchlight is miles away but it illuminates their craft so that they read their instruments without turning on their lights. The beam leaves them and sweeps through the heavens. For an instant the black clouds they have left are faintly brushed by the beam. One of the clouds is many miles distant from the searchlight, but here is an example of

some of the possibilities of searchlight signaling. By flashing a code-message on a distant high cloud, observers far below the horizon have read the message at a distance of a hundred miles.

The airmen have left the storm far behind them. In the distance lies the subdued glow of a city, its light diffusing faintly over a large area of the haze below them. What a variety of different colors are to be seen below them in the lights of civilization, but all dulled and reddened somewhat by the haze. They drop lower and lower in a safe glide. No stunts tonight because the quickness of judgment requires conspicuous reference lines, such as the horizon or the circle of earth for stunting. Down they come to an altitude of five thousand feet. The beam from the searchlight still swings through the heavens, now and then brightening at its upper end as it brushes a filmy cloud and illuminates it. As it swings in a wide arc before them it appears to be reduced to a fainter pencil above this level. From experience and a few indications they conclude this is the upper level of the earth haze, that is, the upper limit of the diurnal convection currents. A searchlight beam is luminous only when it has some reflecting media to illuminate. The dust particles of the haze make the beam luminous just as the path of a sunbeam in a dusty atmosphere of a room is luminous. Above this low-lying earth haze, which often has a definite upper limit at an altitude of five or six thousand feet, the reflecting

particles in the atmosphere are usually much less numerous than in the lower haze. Consequently, the beam of the searchlight appears to diminish in brightness at this level. On occasions when there is no defined upper limit of the haze, the beam appears brilliantly luminous to much greater heights, often stopping in a bright spot as it encounters filmy clouds of the high altitudes.

The airmen continue their descent and now their adapted eyes are able to perceive black patches amid areas of dark grays. The shapes are uncertain and fantastic. Tiny pairs of lights pass along in a straight line far below them. They are automobile headlights guiding families home from their evening's recreation. The automobile is a wonderful development from which mankind is gaining much pleasure and recreation, but the airmen cannot help comparing their evening's experience with those enjoyed by the earthly travelers in the wake of those tiny pairs of lights. They are nearing the ground and must approach cautiously because wires, poles, and trees must be avoided. The field lies yonder bathed in its flood of light. They circle to the leeward and descend cautiously with eyes more intent upon the earth than in the daytime. Its distance must be gauged accurately and the illusions of night must be avoided. They glide toward the ground straightening out cautiously. The wheels touch the ground, then the third point, and the craft glides

over the ground. They taxi back to their hangar and dismount.

As they walk homeward they compare impressions of the evening's experiences, for they could not converse aloft and sign-language was useless in the darkness. They try to express their feelings and emotions while witnessing the storm, but both agree that it "can't be done." No one can do it justice, that is certain. Night flying has its risks but those who live in the present age with its aerial craft that can take them to such scenes in the environment of the mood of darkness, have not fully lived until they have seen them. After such an experience there will be a fuller meaning in Byron's words:

> "Most glorious night!
> Thou wert not sent for slumber!"

CHAPTER XIV

ANNIHILATING DISTANCE

"So it is in traveling: a man must carry knowledge with him, if he would bring home knowledge."

—SAM'L JOHNSON.

IT is a bright cloudless summer morning and two men of the air are astir early, for they have business to transact in a city two hundred miles distant as the crow flies. But distance in these modern times is indefinite when measured in miles. Its true measure is in time and perhaps in convenience. In this sense distance varies with the means of travel and with the coordination of the various kinds of transportation. To arrive in that distant city in time to begin the business day would ordinarily require a night spent on board a steamship or train. Instead, the airmen spend it at home.

The aircraft is brought from its hangar and tuned up. The airmen test the tautness of a wire here and there; they examine struts and give the tail a casual shake. As the engine is warming up they take their seats in the fuselage and leisurely stow away their light baggage. One of

A PANORAMA OF EARTH AND SKY

them opens the throttle and notes how the engine "turns over." At a nod of his head the blocks are cleared away and with a shake of the "joy-stick" to see that the controls are clear, the throttle is opened wide. Down the field the aircraft gains speed, the tail rises from the ground, and the mechanical bird takes to the air. In a few minutes the field is far below and behind them and the craft is on its way boring into the blue toward a certain point of the compass.

On the instrument boards in front of them are maps of the state across which they are to fly to that city two hundred miles distant—two hours barring adverse winds. They mount upward and upward until ten thousand feet is reached, and there unfolds before them a large portion of the state. At this altitude their radius of vision is one hundred and twenty miles. The landmarks are not red schoolhouses and crossroads. They look ahead and see two large rivers and, yes, there is the third one barely visible under what appears to be a bank of clouds. They compare this map with a paper one in front of them. The penciled straight line joining their starting-point and their destination passes through a characteristic bend in the first river and just to the east of the junction of a minor tributary and the second large river. A touch of the rudder and the craft is brought over this same line on the earth-map below them. For a time they will steer their course toward this point on the second river forty

miles to the north of them. Looking downward one of them makes a note of the drift of the craft in the wind; he corrects for this and notes the resultant position of the compass which is to be maintained unless the direction of the wind changes.

Below them nearly two miles are the peaceful farms. The streams and rivers are fringed with a filigree of dark green foliage. A variety of yellows and browns of ripening crops and a multitude of greens of patches of woods, waste, and meadow, all dulled to deep shades by an infinite number of shadows, spread for miles ahead and to the left of them, melted into the sky by the sunlit faint bluish haze. To the right fifty miles away lies the bay which meets the ocean at the cape. Beyond shimmers the ocean in the early morning sunlight and its horizon is faintly visible one hundred and twenty miles away. Alone in space they are conscious of their insignificance. Those small dots in the fields below are men at work, and it seems strange that men should be engaged in earthly labors while they are abroad on wings. Earthly duties seem far away from this dreamland. The feeling of insignificance gives way to one of independence. A touch of the controls and the craft responds. Mastery of the air! What a superb feeling!

The craft bores onward into the north. They pass villages and towns of straggling insignificance. They do not care even to learn their names

because towns are not landmarks for this mode of travel except for short distances and low altitudes. Large rivers are their signposts. There are no clouds about them so the time is spent chiefly in viewing the landscape far below. A thread-like line to the right is a railroad and that slightly bulging splice in the thread is really a limited train. It appears like a jointed worm and, by looking closely, it is seen to be moving along its thread. Yes, it is crawling on schedule unconscious of the speck in the sky which is annihilating distance.

The earth is a varied pattern of very dark shades. The patches of woods are extremely dark green shades—about as dark as the top of yonder gas-tank which has been freshly painted black. A leaf on a tree may be fairly bright compared with a black cloth when viewed side by side, but the condition in the woods is different. Many of the leaves are receiving full sunlight but interspersed among the highlights are numberless deep shadows. The combined effect as seen from the heights above is a very dark shade just as if all the greens were mixed or greatly subdued with black pigment. The same is true of fields and meadow, for here are the numberless shadows on a miniature scale compared with the woods.

The meadows, swamps, and fields of growing crops are not as dark as wooded patches but they are very dark. Their colors vary on this sunlit summer's morning from shades of blue-green and

various greens to the yellows and browns of ripening crops. The first large river is now passing below. It is a brownish color near the shore where the mud or sand bottom is adding its color to that of the reflected blue sky and of the natural blue-green color of water. This brownish color gradually changes to yellowish green as the distance from the shore increases until the color becomes a blue-green in the deep water hundreds of feet from either shore. The airmen recall that, despite the dark shade of the water, it is still twice as bright as the deep ocean water when viewed vertically many miles from shore under the same conditions. Most of its brightness as viewed vertically is due to light diffused within it, as is well known to the observant airman who has often noted the shadows of clouds cast upon water on a sunny day. Water varies greatly in color and brightness as viewed from cloudland.

Now a black spot resembling a pool of ink is drifting beneath. It is a small quiet lake of clear unruffled water. The clear deep water and porous bottom of feathery silt reflect practically no light. The surface, as a mirror, reflects an image of the zenith sky vertically upward but this image is only two per cent as bright as the sky itself. Thus little light comes back toward the airmen from this pool, hence it appears almost black. But this is the airman's mirror. On passing vertically over a quiet little lake the airman is able to see his tiny image reflected by the surface. This

gives him a true vertical which is difficult to obtain with certainty by instruments in an airplane owing to the inconstancy of the speed and the unsteadiness of the craft. At this altitude the airmen could hardly find their image because it would be like looking for an airplane at twice their distance from the earth; however, it is readily seen at altitudes up to a mile or so.

One of the surprises of the air is the dullness of the coloring of the earth's areas; that is, the deep shades which greet the eye. A striking example is met in autumn when the woods are ablaze with a riot of color. From the heights above, this dulls to a dark shade of buff or brown owing to the admixture of the excessive amounts of black in the shadows. Viewed closely the individual leaves are seen and the shadows are ignored. This is the general reason why the brilliant colors of Nature dull to tertiaries when viewed from the air, but, of course, the low-lying earth haze is also more or less influential in this direction.

The details of the landscape are varying continually and their contemplation is enjoyable and restful. The unfolding of the earthly map as a whole is magnificent and as each river comes into view in the distance, one feels a gentle thrill. Bright streaks here and there indicate the works of man. These highways are the brightest objects in the landscape except the sunlit sides of light-colored buildings. Straight lines and symmetry characterize man's works but Nature is devious,

more poetical. Symbolic of this is the stream below. It empties yonder into the larger river at a point only a few miles from its source and its entire course is plainly visible. Its source lies in yonder patch of wooded waste and wanders apparently aimlessly, looping back here and there. It travels far to go a short distance, but does not this stream hold forth a lesson? It is not necessarily aimless; instead, as it journeys to a certain destiny, it is interested in going, not merely in arriving. Rivers and streamlets may symbolize this lesson to aerial mankind. Man may realize his aims even though he dares to be interested in going as well as in getting there. The two airmen will arrive at their destination happier, fuller men by being interested along the way. The poetry of life is along the way and it need not interfere with progress. To see and to admire the sunset on the way need neither to make man late for dinner nor to defer his progress tomorrow.

As the airmen watch the details of the earthly map slip by and philosophize regarding Nature and her ways on this clear summer's morning, the cloud-bank early suspected of lying to the north gradually reveals itself. At this point they are approaching it so rapidly at a mile or so above its level that, apparently, it is drawing like a curtain over the earthly map ahead of them. They drop down at a rapid glide and soon are below its level. Here they quickly sight the particular

bend in the third river which is intersected by the penciled line on their map before them. Noting the drift and the compass after pointing the craft toward this new objective, they give immediate consideration to the cloud-bank. Shall they go above or below it? Their knowledge of clouds and their relation to the weather makes it easy to decide and happily they conclude that they will go above the clouds. Below the clouds it would be dull and dreary; above them lies the blue-canopied fairyland. They rise at an angle which will take them over the rapidly approaching leaders of the pack. As the craft sails over the leaders it "bumps" slightly, for it is not uncommon to find eddies or local air-currents in the immediate neighborhood of isolated clouds.

Soon they are above the vast white vaporous sea and steadily they climb. If they continued their course below this stratum of clouds they might possibly encounter rain or fog eventually. Up above in the sunlight they avoid this possibility and the compass will take them approximately straight toward their destination. If the wind at their altitude should change in direction they could detect approximately the new drift by sighting upon the slowly drifting clouds below them. They are now on an uncharted sea but their compass and their knowledge of the ways of the air are reliable. There only remains a possibility of trouble if the layers of clouds should remain unbroken for the next hour when they should be

near their destination. It is not joyful to contemplate going down through that layer of clouds whose thickness can only be judged from above by their knowledge of clouds. But there is only a remote possibility that the sky at their destination will be overcast because the weather bureau announced upon inquiry before they started their journey that clear weather prevailed this morning throughout the region toward which they are traveling.

The delights of traveling again in cloudland are sufficient compensation for the scanty risks. They enjoy the serene blue of the heavens and the calm snow-white ocean below them. They watch their shadow, arrayed in a delicately colored fringe, glide along the surface of the white sea below, keeping pace with them. The minutes pass and the miles are left behind more rapidly than the minutes. In less than a half hour a dark bluish area appears ahead like a lead in an ice-field. The details of earth gradually appear through this dark bluish opening and soon the layer of clouds is left behind. A glance over the earthly map shows them that they have passed beyond their last signpost—a certain bend in a large river. No other prominent landmarks remain but a careful comparison of the two maps—earth and paper—reveals some small streams, but of more importance, three railroads converging apparently toward the metropolis which is their destination. They check their course and lean

back satisfied. A rough estimate indicates that they should be well within fifty miles of their objective. At their present altitude—eight thousand feet—their radius of vision is over one hundred miles. Why, then, does not the city appear in the distance? The morning has been slightly hazy but the visibility has been fairly good. The faithful tireless motor continues its roar, revolving a thousand times or more for each mile that it forges ahead—over two hundred thousand revolutions for its two-hundred-mile trip. Each revolution has pulled the craft further ahead than the length of a man's step and it makes nearly two thousand of these "steps" each minute. So far it has not hesitated. How the airmen come to admire the faithfulness of a motor, the uncomplaining perfect cooperation of many parts, and the trustworthiness of materials of construction!

Minutes have passed and they should be within thirty miles of their destination. Could it be that they have miscalculated since the passage of the cloud-bank made it possible again to consult the map? With straining eyes, small ghostly-white shapes are distinguished in the distance. Their straight lines indicate the handiwork of man. Then suddenly a metropolis pops out of the haze —a smudge of its own making. The airmen recall this characteristic of large cities for, while the range of clear vision on such a day may extend for fifty or seventy miles at their present altitude,

cities remain hidden in their own smudge until they pop out quite suddenly at close range.

The remaining miles are rapidly left behind and the city grows apace. The airmen drop gradually to a lower altitude; soon they are passing over the residential districts. How interminably extensive that city has always appeared when measured by the tedium of street-car rides and by the meters of taxicabs. But here below them lies the entire city, a huddled mass of miniature geometrical solids, distributed with more or less order. These regular masses are densely packed in the grayish center of the group—the region of terra cotta buildings in the modern business district. Then there is a compact reddish zone of general brick construction and the outlying regions are whitened by the light-colored residences, which decrease in density and end in a scattering at the suburban limits. The whole might have been built by a giant at play with his blocks.

The airmen tumble out of the sky in joyful antics and, at an elevation of two thousand feet, soar across the business section. What a misnomer is the term "skyscraper." In one of these miniature buildings they will soon be transacting business. The airmen look for an oval, for the landing-field is a race-track. The mockery of it! There it lies in the fringe of scattering houses beyond. They search for a smokestack, a bonfire, or even a waving flag to tell them the direction

of the wind. Ascertaining this, they drop down rapidly, head into the wind and fly over the field with eyes alert for its details. With a stiff bank they circle back, and heading into the wind again, they drop gently toward the ground at the leeward of the field. The ground rushes upward; the details which were plainly visible at an elevation of a hundred feet now become blurred owing to the high speed and their proximity. The motor is throttled and there is the slightest jar as "three points" touch the ground. The motor is unthrottled and the splendid craft is taxied to the border of the oval.

The airmen emerge from their cockpits, and alight somewhat stiffly. Are they here in reality, or are they in dreamland? The hour is nine o'clock; business hours have just begun; two hours ago they were at the other side of the state. Have they really soared two hundred miles through the air since breakfast on this glorious morning? Everything points toward reality. As they walk away their gaze lingers caressingly upon that faithful tireless craft, and there is framed in their minds words of grateful admiration for this dream-like heritage of the efforts of brave and learned men who pioneered in the science of flying but who did not live to feel the superb thrills of the mastery of the air. These men and all mankind are obligated more fully to science each hour of the day.

CHAPTER XV

A PHILOSOPHY FOR FLYING

"Did man compute
Existence by enjoyment, and count o'er
Such hours 'gainst years of life, say, would he name threescore?

—BYRON.

IT is not the aim to present a philosophy for air-travel to be adopted universally by persons possessing widely different temperaments but to air a conviction that, in order to extract the most from air-travel, a satisfying philosophy is necessary. Furthermore, it should be stated at the outset that this discussion should not be misconstrued as indicating that flying today is fraught with dangers. On the contrary, there is much evidence, statistical and otherwise, to prove that air-travel is already fairly free from danger. But the air is a new world to mankind in so far as personal invasion is concerned and due to the novelty and strangeness of soaring in cloudland, man experiences a variety of vivid emotions perhaps not unlike those of the backwoodsman who takes his first ride in an automobile through the

congested traffic of a city. The philosophy touched upon here may be faulty and open to many criticisms, theologically, psychologically, or otherwise. It may be unsuited to others in many ways but if it aids an individual, he should cling to it. If it puts him at ease, he is in possession of something which will mark him as a cool one and upon which he will realize large returns for every hour in the air. It will aid him in enjoying to the uttermost not only the beauties of the fairy-land of the clouds, the wonders of Nature's spectacles, and the magnificent panoramas, but the many other thrills of flying. It will permit him to extract something—almost enjoy—those rare moments when disaster seems inevitable. In fact, a satisfying philosophy, through the calmness which it inspires, will sometimes circumvent the grasping hand of Doom.

A philosophy built upon logic or constructed by means of the facts attending a situation appears to have been uncommon among our soldiers and aviators during the recent war. Perhaps relatively few recognized or seriously considered the advantages of meeting the dangers with a mind satisfied by a philosophy built upon facts or logic which would not fail at the crucial point. This does not mean that they did not meet the dangers with determination and brave hearts. It means merely to imply that little has come to light to indicate that sound well-built philosophy prevailed. And why should such a philosophy pre-

vail? Where in the schools, colleges, or churches are men taught the art of living? That living involves intensity as well as time? That the fullness of living depends upon the individual? A painting, a sunset, and life are similar in that man extracts from each that which he puts into each, but in compounded form. Life derives its value from use alone.

It seems that the philosophy of life should be presented somewhere during the schooling of young men and women. In the absence of this, when the nation was forced to make an army quickly, would it not have been a valuable part of the training of soldiers? It seems that it was preferred that the men give little thought to that which lay behind the curtain of the future. But this is like attempting to stem the tide of eternity, for minds will think, notwithstanding efforts to control them, in search of a philosophy which will satisfy. It seems certain that this thinking is not directed logically by the majority of individuals. It is as easy to believe that schools are unnecessary and that each person may educate himself as it is to conceive that each, unaided, may evolve a satisfactory philosophy or attitude toward life. Contemplation under the stress of danger has made many involuntary cowards. It has undermined morale with the result that many have failed in the emergency although their hearts were brave and true. If man cannot escape his own thoughts, is it not best for him to think out, with

the aid of others if necessary, a satisfying philosophy, once for all?

This psychological aspect of warfare and of other activities fraught with real and imaginary dangers is a subject worthy of extensive treatment, but it is not the intention to discuss it at length. It is a subject for qualified psychologists and doubtless there would be many disagreements among them. It is mentioned here because through actual experience or through that of a close friend or relative, many persons realize the importance of mental attitude in the presence of danger or death. Apparently one philosophy found among our soldiers was fatalism. "When my time comes, I'm through" seemed to satisfy many, but is this sound enough to be satisfying in the real critical moments? Others seemed to believe that a certain shell or bullet would have their number on it but doubtless relied with a weak assurance upon its being lost by the wayside during its devious journey to the battle-front. Doubtless some of these further reduced their chances of meeting it by contending that it might be sent across when they were on leave far behind the lines. But were these flimsy philosophies satisfactory in the crucial moments? There is no evidence that those men did not meet their dangers bravely, but who knows with how much inner anguish? Who knows how much intensity of living was ignored or lost during those days of mental stress? A sound philosophy would be

worth much to every soldier, even though it did no more for him than to eliminate the torture of an unsettled mind.

One day two aviators plunged to earth at a training field and were killed before the eyes of a number of their associates. Two of the latter were just seating themselves in their craft when they witnessed the fatal plunge, the outcome of which they could predict before their eyes had followed it all the way to the inevitable crash of doom. One of them turned to the other and stated without the slightest tinge of selfishness, "That's another accident out of our way." Doubtless by some process of intentionally careless reasoning he made himself believe that his chances improved each time an accident occurred—to somebody else. Such an argument did not spring from selfishness for he was a splendid fellow, but he was willing to leave to Fate the distribution of her supply of accidents.

The best that can be said of these philosophies is that there is little sound reasoning behind them and that they are not based upon proved facts. In other words, they are at best unphilosophical. One may banter with himself along the ordinary ripples of life but it is difficult to believe that he will approach the white rapids or roaring cataract calmly with the same joking careless philosophy. It may be that such philosophies as those mentioned would satisfy a large class of persons among whom superstition still lurks and logical

thinking is a novelty. If so, it would be wrong to undermine them without providing a satisfactory substitute; therefore, they are not to be condemned.

The attainment of mental ease or of a self-satisfying attitude toward life is such a personal matter that many prescriptions may be necessary. It is with some misgivings that this brief discussion is included in this little volume because a thorough discussion is unwarranted and even these few pages may appear to be a digression from the main theme. However, the question of fear arises very generally from those who have not yet enjoyed the delights of flying. Furthermore, fear and lack of a definite philosophy have robbed many of those who have invaded cloudland, of much of the joy that waited upon them. Flying is such a new possibility and the results of falling, for instance, are so easily visualized that most persons today think of flying as an activity only for dare-devils and for those who care not how long they live. The evolution of flying during the stress of war gave this activity the appearance of being extremely hazardous. In the hope of aiding to set flying aright in the popular mind this brief chapter is included. In what follows will be found the rudiments or steps which have satisfied some and helped others who desired a philosophy of flying which was based upon a logical array of facts or reasonable arguments.

There are many statistical facts available per-

taining to aviation accidents. The statistics will not be quoted here because they will be superseded as the years pass by still more favorable ones. During the stress of war in which haste, inexperience, and crowded training fields took their toll, there was only one fatality for thousands of flying-hours. At some of the advanced fields few fatalities have resulted during their entire existence. At some of these, many thousand flying-hours were accumulated per fatality. Sitting down before these statistical facts and conservatively eliminating those due to haste, unsatisfactory equipment, congested conditions, and intensive training, the ratio of fatalities and serious accidents to total flying-hours dwindles enormously. There is still another item to be considered, namely, accidents for which the aviator himself is solely responsible. Inasmuch as these constitute a large percentage of the total of accidents, when they are eliminated, those chargeable solely to aircraft dwindle to insignificance. In fact, the final figures are such that an individual may, on the average, live to a ripe old age and still have spent as many flying-hours in the air as he could possibly desire for ordinary recreational and business purposes. This, then, is one of the first steps in building a philosophy.

In the last few years the design and construction of aircraft have progressed remarkably. If desired, an airplane may be designed for high inherent stability so that its control approaches

the ease of driving an automobile. It is reasonable to expect continual improvement for some time to come. From such deductions one becomes satisfied as to the dependability of aircraft and the safety of flying.

Then to philosophize further, one may find it possible to convince himself that *living is a product of time multiplied by intensity;* in other words, that living is not measured in terms of duration. One person may live a whole lifetime with unobservant eyes and unresponsive sensibility and still not accumulate as much living as another who drinks of the joys of life as he passes along a brief interval. From this viewpoint it is essential to compare the beauties, thrills, wonders, inspirations, and emotions in the aerial world with those of the more prosaic worlds with which mankind is familiar. There can be no ennui for mankind in cloudland for a long time to come.

After a person has become satisfied that flying is not dangerous, let him have his first flight with open eyes and alert sensibility, during which, among other things, he will be thrilled with this superb triumph over Nature. He will enjoy the grandeur of the extensive range of vision at high altitudes incomparable with those from earthly viewpoints. On the next flight he may be distracted from contemplation of the earth's distance and hardness by some overwhelmingly beautiful cloudscapes. He may wander in an out at will

among the brilliant white vaporous marvels of fairyland until he cannot believe that anything as drab and smudgy as the earth can exist in the universe. He may begin to appreciate the marvels that the airplane has brought almost to his door. Then let him taste the delights of cross-country flying and his imagination will begin to aid him in appraising this latest triumph of mankind. Finally, treat him to a series of stunts by way of emphasizing the fact that mankind is master of the air. In this wild abandon wherein the craft simulates the freedom of a bird, the candidate becomes ready to consider the philosophy that living is the product of time multiplied by intensity.

The wingless individual in the two-dimensional world at the earth's surface must live years to overtake his contemporary who has spent these glorious intense hours in the air. The searcher after a philosophy for the air may now be willing to admit that in the few hours in the air he has lived as much as though he had spent his allotted lifetime in the less intense living on earth. He may now agree that living "is measured by heart-throbs" and that "it matters not how long we live, but how." He may now calmly contemplate the possible dangers of flying with the thought that he has lived his lifetime and that he will leave the matter of heaping measure to Fate. If the aerial world does not hold forth for him hours crowded with the joy of living he cannot be sat-

isfied in this life, and therefore, should not contemplate with terror the extreme result of an aerial accident. He might logically even look forward with pleasure to his entrance into another life which may possibly hold a satisfying fullness for him. Either way he may philosophize pertaining to the fullness of living in the aerial world should logically prepare him for calmly contemplating that world which lies behind the veil of mystery.

CHAPTER XVI

AERIAL ANTICS

"One crowded hour of glorious life
Is worth an age without a name."

—SCOTT.

THE traveler in cloudland encounters so many new experiences that sometimes he even may doubt the reality of the whole. If he is given to serious thinking he may find himself attempting to appraise aviation in respect to the happiness and progress of mankind. His appraisal, however, is enlarged with each new experience until he is certain that, at least, he cannot overestimate its influence upon the future of civilization. He may marvel at the past accomplishments of aircraft and dream of those to come, but complete mastery of the air does not become a vivid reality until he has sported in space with the wild abandon of the care-free bird. To the aerial traveler clouds have been beautiful; the extensive ranges of vision from the heights of cloudland have been wonderful; storms as seen from above have been awesome. All have been interesting and inspiring; some have been thrilling; but the superb

thrills await those who have not been through a series of aerial antics.

It is commonly observed, "How gracefully an airplane performs stunts but how dangerous they must be." As a matter of fact, such a craft is so ponderous and presents such resistance to motion that grace is a natural result. At sufficient altitudes the so-called stunts are not dangerous when the craft has been constructed with a proper factor of safety. Of course, the strains on certain parts of the craft during these antics are greater than in straight flying but these minor risks may be ignored. At least, they may be compensated by the superb thrills of aerial triumph.

Those whose experience with airplanes is limited to viewing them from the earth generally are impressed with their bird-like movements. Naturally airplanes have assumed the appearance of birds somewhat, because the bird was developed and equipped for flying. If there were available more efficient or practicable principles of flying, doubtless Nature would have developed them in some flying animal. The differences between the appearance of a bird and an airplane are those due, in general, to mechanical considerations of the present time.

After experience with airplanes has been gained in the air, the bird analogy is likely to prove inadequate despite the bird-like appearance of the craft. Straight flying, volplaning, and some of the milder stunts are strikingly similar to the

movements of a flying bird but many of the maneuvers possible in airplanes are not approached by Nature's flyers.

The utmost freedom of an airplane strongly impresses one when in the air. Furthermore, on looking down into the depths of air, somewhat visible owing to the luminous haze, and viewing airplanes far below and on all sides, one is likely to be further impressed with the fact that, after all, the air is fluid. By some such process of analysis and through certain obvious associations, it becomes easy to liken the airplane to a fish free to swim in any direction in its element. To the author the bird analogy is inadequate and the fish analogy has been drawn upon to supplement the deficiencies of the former. This may appear to be a minor point but it is important in awakening the imagination to the possibilities of flying and in aiding in visualizing the details of some of the most startling aerial antics.

An airplane may be controlled in all three planes separately or in combination. If these three controls and the three degrees of freedom are carefully visualized, it is not difficult to determine how some of the more simple stunts are carried out. It would be tedious to read the details of the various definite stunts and it is almost hopeless to attempt to describe in words the vast variety of combinations which would comprise an hour of aerial antics. Words are inadequate to describe the thrills and emotions of the first

experience with this phase of flying, but, perhaps, with the aid of his imagination the reader may gain an idea of what one sees, feels, and thinks.

Perhaps a question might arise as to the advisability of running even the minor risks of stunting. The answers which appear most appropriate are to the effect that into the first half-hour of aerial antics, owing to the intensity of living, the fullness of a year on earth may be crowded and that stunting appears to be one of the most natural play-spells for the airman. Aerial antics serve the purpose of a safety valve for the nervous tension which is incident to the novelty of flying. When one feels himself growing tense, a few minutes of the careless freedom of these antics makes him a complete master of the air again.

Let us assume that an aerial passenger is on his way aloft to be treated to a series of stunts. When the craft reaches an altitude of two or three thousand feet many of the stunts may be done with safety, but inasmuch as nearly every stunt results in the loss of altitude the pilot climbs steadily upward. The passenger wonders all this time when things will begin to happen. The minutes lengthen as the altimeter indicates higher and higher altitudes. Ten thousand feet is reached and still the craft climbs upward. Suddenly it tilts downward at a fair angle and gains speed. The passenger catches his breath and awaits in suspense with his senses alert. The

pilot pulls back the joystick, lifting the elevators, and the craft goes into a loop. The centrifugal force is very great as the craft describes the loop. The passenger feels as if an invisible mighty hand is forcing him into his seat. If he were seated upon a spring weighing apparatus, he would be startled by the fact that he now weighs hundreds of pounds. He attempts to raise his hand but it does not respond. The muscular force which he ordinarily exerts is insufficient to lift it. He tries again, exerting greater force and the hand rises, but how unnaturally heavy it is! It takes much of the power of his arm to raise it. During this time the earth wobbles grotesquely describing a somersault, and then settles to its proper place again. The pilot turns around with a grin showing amid the inexpressive leather and goggles of the rest of his countenance. The passenger has looped the loop but he did not recognize it, for in this first experience the earth did the somersault while the passenger was mystified by many unrealities.

The course of the craft is now bent slightly downward but not such a high speed is attained as before. Suddenly the craft is turned upward into a lazy loop. As it reaches the top of the loop its centrifugal force is almost spent and the passenger feels that the powers are uncertain in their purpose. The centrifugal force which would pull him upward vies with the gravitational force of the earth which would pull him downward. He

hovers in space now touching the seat, now gently hanging by his belt. With head downward he views the distant earth. The craft goes on over, finishing the loop slowly and he notes that this time he has looped and the earth has merely wobbled. After a few loops he becomes accustomed to the unnatural positions and is able to describe a loop while the earth remains quite stationary. This is one of the simplest and most natural antics of the air.

The craft roars onward on full throttle with the passenger wondering what is going on underneath that leather helmet in front of him. Suddenly they shoot upward at a steep angle and the roar of the motor dies down. The craft seems to become stationary; the passenger weighs nothing, at least he does not seem to be sitting with any weight upon the seat. Then the craft drifts backward and downward as if attempting to leave him. A series of these "stalls" come in succession and add thrills.

With throttle wide open the motor roars onward again as the craft maintains its altitude. Apparently this lull is necessary as the pilot thinks up some more devilishness. Suddenly the craft shoots upward as if to do a loop, then, cat-like, it squirms over right-side-up but headed in the direction whence it came. The passenger is in a muddle, for first the earth's surface stood on end and then seemed to whirl on its center for one revolution. He will pass through many "Immel-

man turns" and its close relations before he is able to keep the earth stationary in its normal position.

The airplane continues to tear through space and suddenly the earth's disk seems to be describing revolutions about the axis of the craft. An observer in another airplane would see the craft spinning on its axis as it bored through the air horizontally, or nearly so. The passenger is in a hopeless muddle, for he has no idea of what is going on. From pre-arranged signals the pilot has informed him that they were to do a "barrel roll," and they did.

Thus the passenger is treated to a variety of stunts. Seldom could he recognize the particular stunt the first time he experienced it but, usually, after several successive ocurrences, he is able to note the details as he is passing through it.

Such antics as "dead bird" and "falling leaf" are to him at first just a confusion of somersaults, revolutions, and wobbles by both himself and the earth without any coordination. They were wildly thrilling, even awesome, but he experienced little fear because of the satisfaction of knowing that a sane person was in front of him who was sharing the same risks, knowingly and willfully.

During these acrobatics they have lost several thousand feet of altitude and it is time to begin the tailspin which the pilot has in mind. The craft suddenly leaves its horizontal direction and rises to a stall, but instead of slipping backward at the

high point, it starts to topple over at a steep angle with nose downward. As it reaches the highest point of its upward spurt the motor dies down and the craft remains seemingly stationary in the air. The passenger looks around and there slanting upward steeply from him is the left wing gracefully describing an arc as the craft begins to topple slowly into a nose-dive. Here is a superb moment in the air. It really is a matter of a few seconds which seem like minutes, maybe hours, for although the airplane shortens distance it certainly lengthens time. The passenger looks down upon the intricate pattern of a city. He wonders how mankind can be really interested in such trivial earthly activities as are indicated by the patterns below him. He tries to comprehend the depths of lethargy which make man content to work out those silly pavement patterns in the miniature city park below. He pities those earth beings who live in the drab dullness beneath that smudge of haze. For a moment his glance sweeps the horizon across large bodies of water and thousands of square miles of the earth's surface and he asks himself for the hundredth time, "Is this reality?"

In these few seconds the craft has slowly toppled over until it has assumed the position of a huge bird ready to swoop downward upon its prey, then the pilot puts it into a tailspin. The earth becomes a whirling blur. The whir of the wires and struts overpowers the noise of the weakened exhaust of the throttled motor. The whirling con-

tinues and the passenger becomes aware of a sensation of dizziness mingled with conflicting emotions, as well as thoughts akin to those of the poor sailor on a rough sea. While the craft was slowly and ponderously toppling over he noticed with a flicker of a grim smile, a huge cemetery far below him, its white dots in striking alignment. He recalled with a chuckle the Salvation Army sign which he passed this morning with its timely advice, "Prepare to meet thy God."

As the craft spins downward he finds with the increasing nausea that his interest in life is waning. He has passed through many superb moments but the tailspin itself, depite the supreme moments at its beginning, is not so attractive because it makes him dizzy. But the pilot in glee looks upward with a fiendish grin as the hundreds of vertical feet speed by. The details of the earth's surface are rapidly growing larger. A few clouds at five thousand feet are rushing up toward them. They are heading vertically downward into one. There is a moment of white blindness and they have passed through it but the pilot is no longer grinning. His head is bent and his shoulder is working. The passenger notes the dead propeller, and the cemetery beyond in the same glance, and even connected in his thought. The craft stops spinning and goes into a straight nose-dive. The pilot has pumped up the pressure on the "gas" and is now trusting to a rapid vertical dive for

sufficient air-resistance to turn the propeller over and to start the motor. Seconds ago they emerged from the cloud at an altitude of four thousand feet. The altimeter now reads three thousand and still they are diving straight toward the earth. How hard and foreboding it appears! The passenger's philosophy makes it possible to view the outcome fairly calmly. He even exchanges a grin with the pilot who looks upward as if to gain some devilish pleasure, if nothing else, should a hurried landing be necessary. The altimeter registers two thousand feet, dangerously low at the speed of their nose-dive. The pilot is about to pull the craft out of the dive and attempt a landing when the propeller moves, then it moves again! In a long second or two it has described a half revolution. The exhaust begins to pop, then to roar as the engine picks up. The pilot pulls the diving craft through a huge arc into a horizontal position a few hundred feet from the ground. Then with the controls set for an easy climb he looks back and expresses his feelings to the passenger in the sign language of cloudland.

Possibly those who have not experienced the reality may be able to obtain some idea of what one sees, feels, and thinks during such wild antics. The foregoing is a typical series. During the training of aerial gunners, "machine-gun cameras" were used to some extent. The aerial gunner pursued another craft which tried to evade it, or perhaps two aerial gunners would have a duel

in the air. Such activities called for daring and skill in gunnery and maneuvering. It is here that aerial antics display their usefulness, and one may enjoy them the more when there is a utilitarian purpose behind them. It seems that aerial "camera" gunnery, in which pictures are taken instead of bullets dispatched, might supply one of the future sports or aerial contests because it would measure skill and courage. The photographic records could be adjudged according to definite rules and thus the champion aerial duelist could be determined.

The passenger and pilot are steadily gaining altitude. If they could only meet an airman equipped with a "camera gun" and play "enemy" for him, the passenger's experiences with aerial antics would be well-rounded out. In the excitement of contest he would forget consequences and perhaps find himself on his feet, popping away with his pocket camera as his craft slipped, dived, looped, and climbed. As the aerial gunner swooped around him in wide circles and steep banks, he would gain an idea of the terrific speed of his craft because he now has an object close at hand which makes it possible to appreciate speed. Many in the recent past have enjoyed these superb aerial contests during training for war, but will they be perpetuated as a sport of the air?

In lieu of an imitation enemy the pilot and passenger provide themselves with an imaginary one and the latter gains an idea of fast work in maneu-

vering. The antics which he recently experienced one at a time are now compressed or merged into each other. A steep bank, a close spiral, a tailspin, a nose-dive, evolve in rapid succession, until it appears to the passenger that the pilot's appetite for thrills is insatiable. During all this time they have neared the ground and just as the passenger becomes convinced of the pilot's suicidal intent, the craft side-slips for a thousand feet or more, rights itself over the field, and dips to a quiet landing.

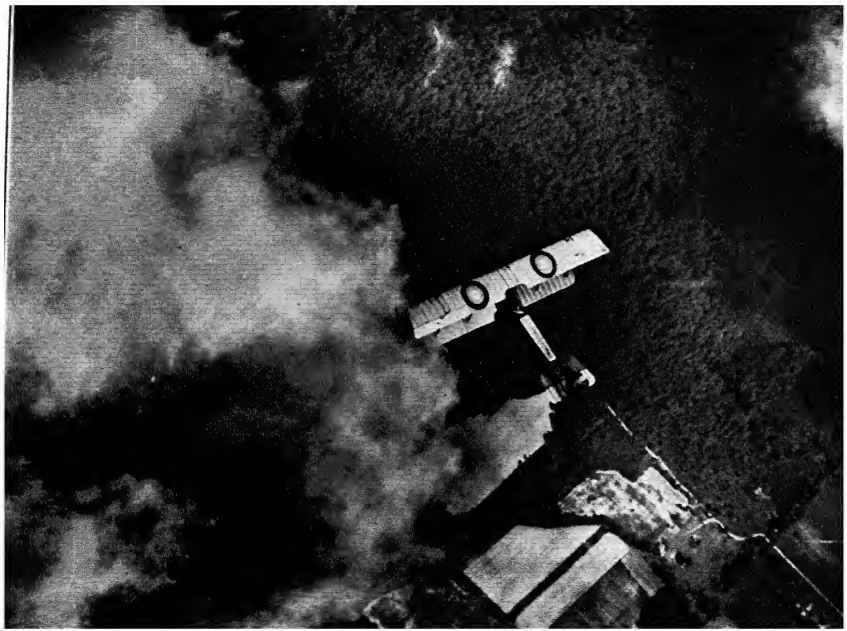
As the passenger walks away there is a note of sobriety or even of sadness in his expression, for he feels that the superb thrills of his life have been passed. From now on, even the aerial world will not yield thrills equaling those of the past hour of first experiences with aerial antics. In all the wide scope of man's past, present, or future accomplishments, his imagination cannot hold forth to him deeper thrills than those of the past hour. But this note of sadness eventually is smothered by the appreciation that the aerial world at least will ever hold in store for him an intensity of living incomprehensible before today.

CHAPTER XVII

THE SUPREMACY OF AIR-TRAVEL

"The best of prophets of the future is the past."
—BYRON.

ALTHOUGH pioneer experiments in the principles of flight were being carried out in the twilight of the last century, the first practical flights by airplanes were initiated after the dawn of the present century. However, tremendous strides in aviation quickly followed and it is difficult to believe that mankind was gasping ten years ago at flying achievements which in this brief interval have dwindled to insignificance compared with the mastery of the air of the present time. Statements of twenty years ago in regard to flying may be read with amusement to-day and they stand as warnings to those who would prognosticate the future of aviation. Ten years ago mankind would have gasped at a world's record flight of fifty continuous miles in as many minutes. To-day the Atlantic Ocean has been spanned in non-stop flights by airplane and by dirigible balloon, and continuous flights by airplane of several hun-



THE AIRPLANE'S COURSE AND SPEED ARE INDEPENDENT OF SWAMP, WOOD OR PRAIRIE

dred miles at one hundred miles an hour are commonplace events of daily occurrence. How long will it be before the earth will be encircled in a single flight?

These statements will be amusing some day, but in order to safeguard them, it may be added that the marvelous development of flying in the early morning of the twentieth century indicates unerringly that greater achievements in aviation will come rapidly. Although prophecy will be avoided, for it serves no important purpose, the supremacy of aircraft of today is deserving of recognition.

The intensive experience with aircraft during the past few years has proved their fitness for many activities. Many of the chapters of this little volume are tributes, inadequate though they may be, to the supremacy of air-travel. Aircraft have opened to mankind the delights of cloudland which he could not enjoy otherwise. The marvelous development of electricity has influenced civilization beyond conception, but the electric motor did not supply something absolutely lacking. Power could be had by other means. However, aircraft are essential for invading the aerial world. This, then, is the first mark of supremacy for aircraft,—it brought the delights of cloudland to mankind and opened to civilization the possibilities that air-travel may afford.

Fiction has already utilized the airplane and dirigible balloon for smuggling, blockade-running, and various other spectacular crimes. More than

one character has circumvented the desperate villain by the aerial route. It is said that truth is stranger than fiction, still all these events have their parallels already in fact.

Earthly obstacles do not alter the course of the aerial traveler. His route may be a straight line except for occasional storms and winds. For this reason, aircraft are already supreme for certain journeys. The straight highways of the air require no maintenance and the aerial traveler needs only to consider their signposts—barometer, clouds, and winds—and look to the speed and endurance of his craft. Mail service is already outclassing that of the fastest trains over the straight paths of prairie country. Aerial mail service, then, may easily outstrip the past methods of mail carriage in mountainous countries. In comparison with water-routes the speed and directness of aerial service reign supreme. Mail from interior Africa, for example, may be carried to European countries by aerial routes in a matter of hours instead of days as is the case of combined land and water-routes.

Hurried explorations of densely wooded, swampy, or mountainous countries have already been accomplished. Forest fires have been discovered with ease from the air. In the lake-strewn forests of Canada a flying-boat has its landing places ever-waiting. The gliding range of aircraft makes high-altitude flights over such countries fairly safe. For each thousand feet of alti-

tude an airplane should be able easily to glide a horizontal mile or two. With long-distance dirigibles, the passengers need give little thought to landing, and travel over the rough wild countries should be looked upon as quite safe. When the more spectacular flights have been consummated, the aerial traveler still will find a vast world to explore by way of the air.

As a convenient and rapid means of getting somewhere, the airplane has thoroughly demonstrated its superiority over any other present mode of travel. Flights of two or three hours replace the tedium of railway or steamship trips which consume an entire day or night. As a means for ordinary journeys the past achievements of aircraft surely indicate a great future. There appears to be little danger in prophecy in this respect except that the imagination can not comprehend the possibilities.

Flying has shown mankind the deficiencies of maps. As the aerial traveler looks down from the heights upon the real map of the earth's surface and compares it with the one on paper before him, he notes the great variations in most cases. Of course, there are many government maps on which such details as the intricate lacework of coastlines and the squirming paths of rivers are recorded with marvelous ability, but the aerial photograph records such details with absolute fidelity. Map-making by means of aerial photography has proved its worth already and there can be no

doubt as to the supremacy of aircraft in many directions in this field.

Already many persons have traveled by air over territory which has rarely been crossed by any other means of travel. The marvel is that the speed of the aircraft is not cognizant of the topography of the surface below. Its speed is just as great over the jungle as over the rolling prairie. In a few hours and with ease and safety to the travelers, aircraft have made trips which could not be made by other modes of travel in less than days and even months of the greatest hardships. It may aid in visualizing the supremacy of air-travel to describe briefly a flight which illustrates this feature of flying. The flight to be described is commonplace in a certain swampy section of the United States, and portions of it at least, have been made by many persons. Similar examples could be found in various parts of the world.

Two airmen are donning their helmets as they walk toward their craft. They are about to start on a two-hour flight most of which is over territory which would be considered otherwise inaccessible. Their course will be approximately circular and in two hours they will complete a trip which could not be made without great hardship in less than months by other modes of travel. Still their preparations are merely for a two-hour flight. One can not help noting the extreme simplicity of the preparation for this trip by airplane, compared

with the outfitting of an expedition to make the trip otherwise.

They take to the air from a field amid the watery tentacles of a large arm of the ocean. As they gain altitude a beautiful landscape unfolds, for underneath them are inlets, tidal sloughs, and streams, each fringed with the dark green lace of bush or swamp timber. On one side, twenty miles away, is the wide mouth of a large river whose winding course may be traced back easily for fifty miles toward its source. Along its way are many silvery threads leading from it to die away amid the green background. On the other side is the mouth of another large river and its relatively bright path may be followed toward its source in the mountains indistinguishable at the distant horizon.

As they mount higher other conspicuous details of the landscape appear. These are chiefly rivers and other areas of water. The water-shed of a whole state is visible within their horizon. They now start on their course. Ahead of them is a huge arm of the sea and the coast-line of the ocean is plainly visible thirty miles away. In a few minutes they are over a body of water which is several miles wide along their course. As they reach a point over land again they find that they have been off the ground only fifteen minutes. They look down at a certain point and recall that they made a trip from the field to that point by launch not long ago in several hours. The water-route is

roundabout and the speed of the launch is slow. Their present route is practically in a straight line and their speed is one hundred miles an hour.

They head straight onward toward the coast over low land seamed with inlets, streams, tidal sloughs, and swamps. Their altitude is fifteen thousand feet and they may glide twenty or thirty miles in case their motor fails. Ahead of them lies the coast-line miles away. The horizon of the ocean is barely distinguishable through the haze and they know by their altitude that it is about one hundred fifty miles distant. The brightness of the sky and that of the distant water are so nearly the same that the haze seems to blend sky and ocean. High up in this sky the white sails of a schooner appear to be suspended but it is merely an illusion due to their height. The angular extent of the water between the coast-line and the distant horizon is so much greater than that with which they are accustomed from earthly views that, for a moment, these white sails appear to be suspended in the sky.

They near the coast-line which bends in a rounded curve forming a well-known cape. Across the wide mouth of the bay lies another rounded cape and in the distance the huge neck of this peninsula is seen to be a network of water and earth. They near the coast and note that the earth below them has become a vast waste of sand, low land, and tidal sloughs. They bank to the right and follow the coast-line. Ahead of them

is a long sliver of bright barren sand extending for many miles and losing itself in the haze off the coast of an adjacent state. The earth below becomes a complete waste, for the trapezoidal areas of cultivated land showing by their straight-line boundaries the hand of man, have now entirely disappeared. A few vessels dot the thousands of square miles of ocean surface visible to their left, but the lonely expanse of water is populous compared with the many square miles of waste below them.

The coast-line of the state to the south of them unfolds and they are able to detect the chief characteristics of the arms of the ocean which give to the eastern boundary its irregular outline. Beyond all this extent of coast-line they see the beginning of the second state to the south. Below them the topography is still the same swampy waste but near the coast it is cut by many shallow indentations as indicated by the yellowish tint of the water. After continuing a few miles beyond the boundary of this adjacent state they describe a huge arc and head westward. Their course now leads them across the heart of this extensive swamp. Down below, the earth appears to be covered by a vast forest. Indentations of water have disappeared to the rear but they detect the sparkle of water here and there amid the dark green foliage of the timber. They are now over one of the great wooded swamps of the country. Ahead of them lies a circular lake two or three miles in

diameter, alone, without apparent inlet or outlet amid this area of wooded waste.

They have often discussed the results of a forced landing on top of this scrubby timber and have decided that a congested district of a city would be more suitable. Here, with many miles of swampy woodland between them and civilization, the only succor which could arrive in time to be of value to them would be a dirigible balloon. Their tattered craft in the treetops would point the way and their rescue may be left to the imagination. Despite these thoughts they are tempted to see this dark forbidding swamp at closer range.

Far beyond them in the distance the familiar areas of cultivated fields are seen making their way into the outskirts of this waste. With these distant fields in view their altitude insures comparative safety; however, they throttle the motor and glide downward. The details below them rapidly grow larger and soon they see the water glinting everywhere through the treetops. They continue their downward glide and as the altitude decreases, the swamp appears more forbidding. Their nerves grow more tense and their eyes and ears are alert. A single "miss" of their motor would lead to immediate action. Down and down they glide and, finally, risking the chance of a failing they dip for a skim over the treetops. Just before they reach their low point the throttle is opened and with a roar of disdain the motor pulls

them rapidly upward out of reach of the watery waste. They have been within a hundred feet of the heart of the swamp, an added thrill to their journey.

They continue to climb and when the earmarks of civilization appear below them they are at an altitude of many thousand feet. Large cities lie in the distance as shown by the characteristic smoky haze. They alter their course toward them and soon the details of the cities become visible. Their altitude is again fifteen thousand feet as they soar over them. The details of the harbor, the little thread-like wharves, the alignment of the tiny city blocks, the parking along the waterfront, and a vast number of details of two large cities are spread in miniature nearly three miles below them. Their craft is a tiny speck to the inhabitants below and doubtless is not seen. The position of their landing field can be distinguished several miles inland beyond the far shore of the wide strip of water below them. They know that it lies between the second and third arms of the bay beyond, for the real map of the region as seen from the heights of cloudland is well impressed upon their memory.

As a safety valve for their nerves which are in tension despite their calmness, they dip the craft upward and topple into a nose-dive. Down they go at a tremendous speed. The thousands of feet of altitude rush past as the city spreads rapidly and comes up to meet them. Then with a swoop-

ing curve, they straighten out and cross the several miles of water toward home. They look backward at the swampy region in the distance. At their present low altitude it is merged into the greater depths of haze. The horizon of the ocean is no longer distinguishable because it lies beyond through the maximum depth of haze. They are back in the smudgy atmosphere of the earthly world. The field rapidly spreads before them; they dip into a gentle glide and land.

They have completed a trip which they have made several times before. Superficially to them it is merely a two-hour trip but they know that the topography of the course on earth is such as to mean months, perhaps a year, of the hardest toil to cover the course in any other way. They need no convincing regarding the supremacy of air-travel.

CHAPTER XVIII

METEOROLOGY

"Knowledge alone is the being of Nature
Giving a soul to her manifold features."
—BAYARD TAYLOR.

METEOROLOGY is the science of "things of the air" and its development is extremely important to civilization. The aspect of this science which touches mankind in general is that dealing with the weather,—past, present, and future. Weather forecasts and storm warnings as issued by the Weather Bureau are correct about eight times out of ten despite the facetious banter hurled at the official forecaster. The present impossibility of obtaining simultaneous data over a large portion of the globe and at sufficient altitudes adds to the difficulties of forecasting in such a matter as weather which has so many influences acting upon each other. Nevertheless, the public should encourage the development of the science and should interest itself in those details at least which pertain to the weather. Those who will read the official forecasts and watch the signs

in the sky will seldom become victims of a weather surprise.

Meteorology is the science of the great sea above which has always meant so much to mankind and now that the air has been invaded and is to become a highway of travel, a widening usefulness of this science appears. The meteorologist will be looked upon for prognostications regarding "flying" weather. He will be expected to map the air-currents in order that the traveler may avoid unfavorable winds or may take advantage of favorable ones. If the aerial traveler hitches the wings of the wind to those of his craft he may often increase his distance traveled in a given time or reduce his time for a given distance very greatly. Even the aerial traveler himself should be acquainted with the general facts of meteorology if he would be best equipped for venturing into the air. On the other hand, air-travel doubtless will contribute much knowledge to this science.

The earliest myths indicate that civilization before the dawn of history was interested in the "things of the air." From early literature it is possible to gain an idea of the climate of the country whence they came. Doubtless, there were persons in all ages who acquired skill at forecasting the weather but the first systematic records of which there is any knowledge do not date back farther than the twelfth century. These records and those of succeeding centuries were entirely

STREAMS AND RIVERS AND SEAS ARE CLOUDS AWAITING RESURRECTION.
THIS ENDLESS DEVIOUS CYCLE TYPIFIES THE METEOROLOGICAL CYCLE

those of individuals until the middle of the nineteenth century. During the latter half of the last century national organizations began to take up a systematic study of meteorology and today every civilized nation has its weather bureau or meteorological office.

The invention of the telegraph made it possible to obtain simultaneous reports from many sections of a country so essential to systematic study and prognostication. The laying of the ocean cables extended the area from which simultaneous reports could be obtained and wireless telegraphy made it possible for ships to exchange observations with land stations. Thus the web of stations has been built up and with the addition of air-travel, the development of meteorology should grow apace. Today it may be said that weather and storms may be predicted a day or two in advance with sufficient accuracy to be of valuable service in many ways and to justify the cost of such work. The science is so important and interesting that every person should be stimulated to give it at least casual attention. Furthermore, it is such a vast field and so fraught with mysteries and difficulties that it should be attractive to the best scientific talent.

Modern meteorology includes a study of all the phenomena of the atmosphere of gases, dust, and clouds which surround the earth and extend to that unknown and undefined region of so-called interstellar space. The collective influence of these

many phenomena results in what is called climate, hence, their collective study is that of climatology. It is not the intention to go deeply into the subject of meteorology but a general view may awaken in the reader an interest in the vast aerial world now literally opened to him by the advent of aircraft. Many details have been interwoven in other chapters but repetition will be avoided in so far as possible. At best, the present survey will be merely a hurried one aiming to point out the general aspects of an intricate science.

Obviously the content of the atmosphere is of prime importance. Oxygen and nitrogen comprise nearly the total amount of the atmosphere. The relative proportions of the various gases remain practically constant up to an altitude of seven miles, or in the region of convection currents. The relative proportions of oxygen and nitrogen vary only a fraction of one per cent over the earth's surface and these variations seem to be related to regions of high and low barometric pressure. Carbon dioxide varies slightly with the exposure of the locality to wind, increasing somewhat in proportion to the amount of shelter. It is generally present in slightly greater amounts over land than sea. These variations are of scientific interest but not of everyday importance.

Water-vapor is present in very small proportions but these small amounts are exceedingly important to mankind. Dry dust-free air is quite transparent to the radiant energy from the sun,

but the presence of water-vapor makes it quite absorbing of the so-called "heat rays." In fact, on the average, only about sixty per cent of the radiant energy from the zenith sun which is incident upon the upper atmosphere reaches the earth on a clear day. As the sun decreases in altitude the depth of atmosphere greatly increases, hence, the greatest percentage of the energy from the sun reaches the earth at noon. Clouds act as the earth's surface and absorb and reflect most of the radiant energy from the sun, hence, it is cool in the shade of a cloud.

Interstellar space may contain molecules of the highly volatile gases of the atmosphere which escape from the earth's gravitational force. The refraction of light, twilight, shooting stars, and the aurora indicate that something material exists in appreciable quantity as high as one hundred miles at least. Shooting stars suddenly become luminous by friction when they strike the upper atmosphere. The aurora is supposed to be similar to electrical discharges in vacuum tubes, and is generally accounted for by the presence of electrons expelled from the sun and sent out through space, finally to produce luminous displays in the extremely rarefied regions at the outskirts of the atmosphere.

The circulation of the atmosphere is perhaps, the most important phase of meteorological studies, for weather and climate are dependent upon it. Doubtless, in the heights of the atmos-

phere quite free from the multitude of influences found at or near the earth's surface, weather and climate are synonymous—always the same. However, in so far as mankind is immediately concerned the large local changes in weather are due to the mechanical and thermodynamic interaction of earth, ocean, and atmosphere. The winds are fascinating in their magnitude, variety, and relations to each other and to other phases of meteorology. Systematic studies and simultaneous reports have done much toward ascertaining the laws of these supposedly whimsical and unruly currents. Owing to their importance they are treated in another chapter. They have been studied at high altitudes by observations on clouds and by means of kites and balloons. The clouds reveal much pertaining to the winds and they are available to the amateur as well as to the meteorologist.

In the development of theories, so essential for the purpose of scientific explorations, the meteorologist must obtain all the physical data possible pertaining to the air. Therefore, he studies such physical characteristics as specific heat, density, expansion, elasticity, diffusion, viscosity, friction, gravity, temperature, and pressure.

Cloudiness is a factor in climate and the details of the clouds reveal much to the forecaster; consequently, reports of types of clouds are recorded and the percentage of cloudiness is determined daily at various stations. The average cloudiness

is intimately related to the density and circulation of the atmosphere.

The apparatus used by the meteorologist in recording the manifold observations are very extensive. Many of these are recording instruments which eliminate the necessity for personal attention. Such recording instruments are obviously of great value for attaching to kites and to balloons. By means of them attached to small balloons, data pertaining to the atmosphere as high as twenty-two miles have been obtained.

Various types of thermometers are used varying in principle, range, and sensitiveness.

Barometers record the atmospheric pressure. These are of various types. The altimeter used on aircraft is merely a barometer of the aneroid type which is calibrated to read altitudes instead of atmospheric pressures, there being a known relation between these two factors.

The anemometer measures the velocity of the wind. Those used at land stations consist usually of cups which revolve in the wind at the end of arms. The speed indicator of aircraft is really a wind-gauge of another type and measures the speed of the craft in relation to the air. Obviously, this does not measure the speed of the craft in relation to the earth. An airplane capable of a speed of one hundred miles an hour in still air, on heading into a fifty-mile wind, has a speed in reference to the earth of only fifty miles an hour. However, in the opposite direction its speed in

reference to the earth would be one hundred and fifty miles an hour. This accounts for some of the "record" flights commonly reported.

The hygrometer indicates or records the relative or absolute humidity of the air, and, therefore, yields data pertaining to the quantity of water-vapor present. The quantity of water-vapor which air will hold before it becomes "full" or saturated increases with the pressure and temperature, hence, these quantities must be considered in connection with hygrometer records.

Rain and snow gauges supply the data pertaining to precipitation. These are usually simple receptacles but their forms have been the subject of careful study.

By means of the evaporometer the quantity of water evaporated from a given area is determined. Obviously, this is determined by the "thirstiness" of the air, that is, by its relative humidity. The rate of evaporation, other things being equal, is directly proportional to the difference in temperature indicated by wet and dry bulb thermometers. It increases with the wind velocity. Sea-water evaporates five per cent less rapidly than fresh water. The size and shape of the area from which evaporation takes place influence the rate of evaporation.

Various devices are available for determining the direction and apparent velocity of a cloud. The heights of clouds may be determined by triangulation, that is, by taking simultaneous obser-

vations at two points at a sufficient distance apart.

Several types of sunshine recorders are in use. They are based on chemical and thermal principles. Obviously, sunshine may be recorded photographically or by charring a moving paper in the focus of a lens.

Various kinds of electrical apparatus are in use to obtain electrical data pertaining to the atmosphere too varied and too specialized for discussion here.

Dust particles are important from various standpoints. They absorb sunlight and they decrease visibility but they are useful as nuclei upon which water-vapor condenses. If an enclosed glass vessel contains a layer of water, the air above the water will be saturated. If the capacity of this air for water-vapor be reduced in any manner, such as by suddenly reducing the pressure, a cloud will be seen to form. This experiment may be performed easily by having a rubber tubing connected to the bottom of the vessel and to another vessel containing water. The reduction in the pressure of air in the former may be obtained by suddenly lowering the latter. By raising the latter to its original level the original conditions may be obtained again. After repeating the process two or three times, each time permitting the cloud to settle upon the water, it will be noted that the cloud will no longer form. The dust nuclei have been used up. If cigar smoke or electrified air be admitted, a dense cloud will be

easily formed. Dust counters are used by the meteorologist and it has been found that the number of dust particles in a given volume or mass of air decreases greatly with altitude and varies with locality

The brightness of the sky is of importance and is measured by means of a photometer. The blueness of the sky is also recorded.

The intensities of visible sunlight and of total radiant energy from the sun are studied systematically.

The preceding paragraphs indicate in the briefest manner, the intricate web of the science of "things of the air." From systematic records much has been learned of the laws of the wonder-world above the earth's surface, but much remains to be explained. However, weather-prognostics are now upon a basis of fact and are fairly reliable. Although weather forecasting is not the sole aim of the meteorologist, it is the most important phase as far as mankind in general is concerned.

The barometer is perhaps the best single tool of the forecaster. Immediately after its invention, nearly two hundred years ago, systematic observations showed that, in general, a low barometric pressure preceded rain or snow; and a high pressure attended fine weather. The systematic simultaneous observation of atmospheric pressure, of temperature, of direction, and of velocity of the wind and of the condition of the sky at many

places yields much data which, when placed upon weather charts, make it easy for the meteorologist to prognosticate with a fair degree of accuracy. The paths of cyclones or areas of low pressure are fairly well established by previous records.

Everyone knows, in a general way at least, that the Weather Bureau issues such maps daily. If one will take the pains to interest himself more in these weather maps he will find much interest in watching the progress of the cyclones and anticyclones across the country. The former are enclosed by more or less circular lines (isobars) each of which represents the regions possessing the same barometric pressure. The anticyclone is the region of high pressure and is enclosed by isobars each indicating the localities of the same barometric pressure.

Systematic data on temperature show that many meteorological elements, which otherwise may appear capricious, to be related to the isotherms (the lines connecting localities of equal temperatures). Such data have revealed a definite part played by the distribution of land and sea, for example:

In the days of sailing vessels the systematic tabulation of winds at sea resulted eventually in shortening many ocean voyages because the skipper was enabled to take the course showing generally favorable winds, and he learned also to avoid the doldrums or extensive equatorial calms.

Average statistics numerically represent cli-

mate but are of little value in foretelling the weather. The daily records combine to show the weather over a large section of the earth and then serve as statistics from the accumulation of which many generalizations have been discovered.

The science of meteorology still rests largely upon pure observation. The "synoptic" charts compiled from observations taken at the same time of day enable the meteorologist to take a bird's eye view, as it were, of the weather conditions over the country from day to day. From these charts it has been discovered that the configuration of the isobars assumes several well-defined forms; that the wind takes certain definite directions relative to the trend of these lines; that the velocity of the wind is usually proportional to the closeness of the isobars; that the weather is related to the shape of these lines; that the positions of these lines are constantly shifting; that many other details of weather are usually related to the isobars in a systematic manner.

The whole meteorological scheme which appears chaotic to the casual observer becomes very much simplified when analyzed, and gradually by the accumulation of records, the tangled web is being unraveled.

CHAPTER XIX

WINDS

"Wild spirit which art moving everywhere,
Destroyer and preserver; hear, oh, hear!
Thou on whose stream, 'mid the steep sky's commotion
Loose clouds like earth's decaying leaves are shed,
Shook from the tangled boughs of heaven and ocean,
Angels of rain and lightning; there are spread
On the blue surface of thine airy surge,
Like the bright hair uplifted from the head
Of some fierce Maened, even from the dim verge
Of the horizon to the zenith's height,
The locks of the approaching storm."

—SHELLEY.

THE casual observer perhaps thinks of the invisible ocean of air as mere space but on further thought he must attribute weight or mass to this invisible sea. The barometer indicates that mankind lives at the bottom of a fluid which exerts a mean pressure at sea-level of slightly less than fifteen pounds per square inch. This pressure is ordinarily unnoticed by man because it is equalized throughout the porous structure of his body. However, when he ascends to high altitudes in an

aircraft or up the mountain side, he notes symptoms which he has learned to attribute to decreased atmospheric pressure. Man lives at the bottom of this sea which rapidly diminishes in pressure and density as he ascends from the bottom. From various considerations the extreme upper limit of this atmospheric ocean is at an altitude of from fifty to one hundred miles, but the pressure decreases so rapidly with altitude that the upper surface is not defined as is that of the less compressible and less volatile sea of water. In fact, the airman has left half the total weight of air below him before he reaches an altitude of four miles and this rapidly diminishing density limits the heights to which balloons and airplanes may ascend.

Air, having the property of mass in common with all material substances, also possesses inertia and it is this property that lends force to the wind which drives windmills, speeds schooners on their way, and blows down trees. The propeller of an aircraft encountering this inertia of the air, which it possesses by virtue of its mass, propels the craft through this invisible sea much in the same manner that the submarine is propelled in the ocean of water.

The magnitude of this ocean of air and a conception of the force of its currents perhaps may be obtained from some approximate figures. The average pressure of air on each square foot of the earth's surface is approximately one ton. The

weight of the air above each square mile of the earth's surface is approximately thirty million tons. The area of the surface of the earth being approximately two hundred million square miles, the total weight of the ocean of air is represented by an incomprehensible value, namely, about six billion million tons.

The general circulation of this mass of air determines weather and climate and is now of a new importance inasmuch as mankind has learned to ascend from the bottom of this sea and navigate its lower strata. There are certain great general movements of the air, upon which many minor currents are superposed. A river affords an analogy with its bends, eddies, whirlpools, ripples, backwaters, and varying currents, but despite these, there is the general trend.

Atmospheric circulation is a gravitational phenomenon caused by temperature differences; that is, it is due to the different weights of equal volumes of air of different temperatures. The circulation of water of different temperatures is a helpful analogy. Water in heating or cooling systems, in the teakettle or in the ocean, circulates in a complex, though law-abiding manner. The magnitude of the atmosphere, the manifold influences, the lack of data pertaining especially to high altitudes and latitudes, render it impossible at present for meteorologists to explain atmospheric circulation completely or to map out all the details.

The heated air in the equatorial region rises

and there is a higher pressure established at the equator than at the poles. As a consequence of this pressure gradient, air flows toward the poles. On its way toward the polar regions it cools and sinks toward the earth, eventually to return to the equatorial region to begin its cycle again. Some of this air returns near the surface of the earth but it is thought that high up in the stratosphere, in regions above ten miles, there may be steady winds from polar regions toward the equator. This conclusion seems plausible because the temperature of that high region is lower over the equator than over regions of higher latitude.

Such permanent temperature contrasts are chief factors in atmospheric circulation. On a very much smaller scale are the land and sea breezes. During a summer's day the land heats more rapidly than the sea; hence, the air rises over the land and a pressure difference or gradient is established. The air from over the sea flows over the land in a natural attempt to equalize this pressure; hence, the sea breeze is born. At night the land cools more rapidly than the sea and it finally becomes colder than the water. A land breeze then flows out over the water. These currents are gentle as a rule and do not extend far inland or to sea.

If the earth's surface were smooth and of a uniform composition and if the earth did not rotate about its axis, the general circulation of the atmosphere doubtless would be simple. Air would rise

from the equator and flow north and south to the respective poles and return in simple paths. However, there are many factors which influence the general circulation of the atmosphere, a very important one being the rotation of the earth. Any mass at the equator possesses a certain momentum proportional to the velocity of the surface of the earth due to axial rotation. The west-to-east velocity of a point on the equator is about one thousand miles an hour, hence, the rising equatorial air possesses this velocity toward the east. The pressure gradient from equator to pole causes the air to tend to flow north in the northern hemisphere, but owing to the west-to-east velocity of the air, its actual path is toward the northeast. This point will be clearer if it be noted that the velocity of the earth's surface due to axial rotation diminishes gradually to zero at the poles. As the equatorial air reaches higher latitudes its "equatorial" west-to-east velocity causes it to "get ahead of the earth"; hence, in this hemisphere it sheers toward the right as it travels toward the north pole.

This tendency toward the right adds one of the many influences which result in extreme complexity by building up a pressure gradient from east to west, because the air tends to pile up on the right and diminish on the left. Of course, there is a very great resultant retardation due to friction, viscosity, and many other causes. This current gradually descends as it leaves the equator

behind and in the temperate zones is practically a surface wind. This may give a glimpse of some of the chief influences which are the laws behind the general circulation of the atmosphere. Perhaps a further idea of the causes of aerial currents may be gained from brief discussions of characteristic winds. It is understood that the directions of winds are those from which they blow. For example, a west wind is one blowing from west to east or a current in which the air is traveling from west to east.

The foregoing accounts for the prevailing westerly winds in the United States but, of course, there are permanent and temporary diverting influences. The distribution of land and sea accounts for certain temperature differences of sufficient magnitude and extent to become a powerful influence upon the course of even the great flow of air from equator to pole and return. These temperature differences depend upon the season and may actually reverse from summer to winter. Hence, there arises certain prevailing winds with respect to land, water, and season.

On a more local scale the topography of the earth may cause a permanent diversion of the general trend of the wind. But all these prevailing winds in the stratum of air below an altitude of seven miles in this zone are continually being influenced and even temporarily overcome by cyclonic storms, anticyclones, and even the more local disturbances.

If air is heated locally, whirlwinds may be generated; cumulus clouds may be formed by condensation of the water-vapor due to the cooling of the rising vapor-laden air; breezes may flow down valleys to replenish rising air; sea breezes may blow inland to replace the air which rises over the heated land.

If air is locally cooled, breezes may blow from land to sea at night or in winter; air may fall down from mountain tops, giving rise to mountain breezes; winds may blow out of the cavities of glaciers or out of caves; various local winds may arise from cooled sources; the sluggish drainage winds over extensive areas known as continental fall-winds are formed. The ice-caps of Greenland and of Antarctica produce strong and fairly continuous fall-winds. These extensive cold areas control the direction and velocity of the local winds of the regions and are so extensive as to influence the general circulation of the atmosphere over large portions of the globe. The extensive area of Antarctica and its low temperature cause strong continuous surface winds averaging in some localities on the edge of this polar cap as high as fifty miles per hour for the entire year.

If extensive areas are continuously heated and cooled respectively, gradient winds are born such as those across flat desert regions. Besides these are the trades, antitrades, monsoons, cyclonic winds, and anticyclonic winds. Over level regions gentle gradient winds are of highest velocity in the

early afternoon and are least at about dawn. Their depth above the earth's surface is usually only a few hundred feet which is less in winter than in summer. There is a tendency of the wind to change slightly during the day with the sun, that is, to follow the hottest region. Obviously, this weak tendency is usually masked by more powerful influences.

The normal state of atmospheric circulation in middle latitudes is a definite west-to-east velocity, therefore, other winds and calms are really disturbances.

The trade winds are very constant over the tropics and are peculiar to the oceans. They usually have a large east-to-west component. In the higher latitudes of the tropics of the northern hemisphere they generally blow from the northeast, that is, they are northeasterly winds. As they approach the equator they tend to become east winds. Their steadiness, upon which early commerce depended, won for them their name.

Calms, of course, may appear any place if there is no pressure gradient, but the doldrums near the equator are famous. They are found in peculiar depressions between the northeast trades of the northern hemisphere and the southeast trades of the southern hemisphere. The southeast trades gradually change to east winds as they progress north toward the equator in quite the same manner as trades of the northern hemisphere.

The heated air which rises from the equator to

A FROWNING SQUALL-CLOUD

begin its journey toward the poles changes, in the northern hemisphere, from an east wind near the equator to southeast, south, southwest as it progresses northward, becoming nearly a west wind as it enters the temperate zone. That portion which goes south changes in a similar manner from an east wind to northeast, north, northwest and finally becomes practically a west wind as it enters the south temperate zone.

The antitrades are of the same depth as the trades and are merely an overhead continuation of the latter. The trade winds ascend as they approach the equator and flow poleward, thus producing the antitrades of general atmospheric circulation. They return eventually to the equator to begin again their cycle, from trades to antitrades, and finally to westerlies of middle latitudes. These, of course, are modified by many secondary air-currents, storms, etc.

Monsoons are the winds caused by seasonal differences in the temperatures of land and water and, therefore, bear the same relation to summer and winter as the land and sea breezes bear to night and day.

Thunderstorm winds are due to excessive temperature contrasts of adjacent local heating and cooling. Shortly before a thunderstorm takes place at a given locality, a south wind may be blowing. When the storm is near, the wind begins to blow from the storm and when rain is close the wind becomes violent from the storm front.

This wind is usually gusty for a few minutes, then becomes steady. After the storm has passed the wind generally assumes its original direction.

There are many definite forced winds caused by other winds or by the earth's contour. These may be represented by tornadoes, water-spouts (tornadoes over water), chinooks, and various eddies. The earth's contour and various obstructions obviously cause eddies. The chinook or foehn is a dry wind blowing down a mountain slope. The tornado usually precedes a thunderstorm and apparently the whirl is induced by adjacent strong currents of air flowing in opposite directions. When the circular path is once established, a well-known physical law accounts for the tremendous velocity in the small part of the funnel near the earth. There is a tendency for the product of the velocity times the radius of the circular path to remain constant; therefore, as the cross-section diminishes toward the lower small end of the funnel, it is obvious that the velocity must greatly increase. Velocities as high as five hundred miles per hour are estimated to exist in the smaller portions of the funnel of a tornado, but the actual translational velocity is low, usually about twenty-five miles per hour. Tornadoes are peculiar to the United States and invariably travel from west to east, usually toward the northeast. They are often called cyclones but in meteorological terminology the term cyclone is applied to a storm of much greater area and is a system of winds whose

center is an area of low barometric pressure or a "low" as it is called.

The cyclone and its antithesis, the anticyclone, are perhaps the most important atmospheric phenomena to mankind, for they usually dominate the local weather conditions. Strong winds and heavy rain or snow in the temperate zone are associated with a barometric "low." Moderate and gentle winds and a clear sky are associated with a barometric "high." The anticyclone is the system of winds whose center is the "high." The average diameter of a cyclonic storm in the United States is at least one thousand miles. Although some of these cyclones remain stationary or nearly so and thus may be termed semi-permanent, they travel in general at an average speed of about twenty miles per hour, in a general west-to-east direction in middle latitudes. In the northern hemisphere they generally have a southerly dip over continents and a northerly dip over oceans. These storms from the west coast of the United States travel generally eastward, with a southerly dip in the region of the Great Lakes, then following the direction of the St. Lawrence river, they leave this continent through Newfoundland.

The direction of the winds in a cyclonic storm-center may be described briefly in the following cycle: counter clockwise around the barometric low, spirally inward and upward, thence, outward as they gain altitude. This process takes moist air to high altitudes where the filmy clouds which

are formed are spread by the high winds of the upper regions over a large front far in advance and to the sides of the storm-center. The cyclone is a huge whirlwind usually of hundreds of miles in diameter. The anticyclone is the system of winds blowing out of a central "high." These "highs" and "lows" are seen on the weather maps and one may find a fascination in viewing the progress of these large disturbances across the continent. Such maps are bird's-eye views of the essential meteorological data in connection with the general weather of the entire country. From systematic observation of these maps and of the sky one will be rewarded by much of interest and eventually by a comprehensive knowledge of the laws and eccentricities of weather.

In the preceding paragraphs an attempt has been made to give not only a general idea of atmospheric circulation but also to present the characteristics of various distinct types of winds and their causes. It is seen that there are many factors which influence the currents in the aerial world. Even the earth's rotation is a fundamental influence, and besides the resultant effect already mentioned, there is the effect of the curvature of the earth. The deflective force due to the earth's rotation and the horizontal component of the centrifugal force due to the curvature of the path are at right angles to the course of the extensive winds from the equator to the poles, hence,

they affect the direction of these winds. The pressure gradient due to gravity not only influences the direction but also the speed of winds.

It is well known that winds increase in velocity with elevation. The actual velocity close to the surface of the earth is very irregular and it increases with elevation more rapidly when the average velocity is high than when low. There is usually a rapid increase in velocity up to an elevation of about one thousand feet above the surface of the earth. Obviously, this is the region where surface friction and the disturbances and retardation therefrom are effective. Next there is a region, from about one thousand to five thousand feet, of irregular winds very slowly increasing in velocity with altitude. Throughout the region from elevations of about one to seven miles, the velocity of the winds increases steadily with altitude in the middle latitudes. These winds, out of reach of frictional retardation and the ordinary vertical convection currents, possess velocities quite proportional to the pressure gradients. These velocities reach two hundred miles per hour. In the stratosphere, that is, above seven miles in the temperate zone, the average velocity appears to be less than just below it.

Although there are many uncertainties pertaining to atmospheric circulation, some generalities have been arrived at which may be of interest. Apparently there is no great overflow of air at

all in localities from the equator to the polar ice-caps. At elevations of six or seven miles the wind seems to have southerly components as frequently as northerly components. This is an indication that the circulation from the equator toward the poles is complex at even higher altitudes. The equatorial winds are not consistently easterly at all altitudes. In fact, west winds are observed at altitudes of ten to twelve miles and east winds have been observed at higher altitudes. There are strata of air in which the temperature sometimes increases with elevation and sometimes remains stationary. This condition has been observed in various localities from the equator to the polar regions. The pressure gradient of the upper atmosphere toward the poles is small in the polar regions and reaches a low value even in the northern portion of the temperate zone. Furthermore, the winds in the polar regions are not consistently westerly. The upper winds are exceedingly variable in certain regions.

The phenomena of the circulation of the atmosphere are numerous and their combined influences make a complex web. However, the subject may be easily studied by anyone and surely the advent of the aerial age has made the winds a subject of general interest. Winds do not merely whip the clouds into interesting and beautiful forms, thereby revealing themselves and adding variety to the sky, but they serve very useful purposes.

They help to make this earth inhabitable. Now that man has invaded the aerial world he must learn more of the winds so that he may avoid those which do not suit his purpose and harness those which do.

CHAPTER XX

WEATHER AND THE SKY

"And the hooded clouds, like friars,
Tell their beads in drops of rain."
—LONGFELLOW.

IT is astonishing that the sky with its variety of beauty and moods does not have more admirers and interested observers. It can not be that it is outclassed by other areas or aspects of Nature because it occupies a prominent position in landscapes and it is usually a dominating area. Furthermore, its displays often overwhelm other aspects of Nature in variety of color, pattern, and mood. It is the only part of the great open places that follows civilization into its bewalled cities. But it is even more astonishing that the sky does not attract more observers with its utility as a weather-indicator so definitely established. The average city-dweller and many villagers look with awe upon the ability of the farmer, the sailor, the woodsman, and others who live in the open places to foretell the weather. And this ability assumes an uncanniness because the forecasts of these

prophets are so often made either in picturesque weather-lore or in such a manner as to bestow the ability of self-expression to inanimate objects apparently unrelated to the weather. For example, the Indians had a sure sign of pending rain when the "scalps" hanging among their trophies became damp. Obviously, if these objects are hygroscopic they will get limp or damp in humid air just as salt and cellar-walls indicate humidity, and such moist air is often the forerunner of rain.

Doubtless, most of the weather-lore was fairly dependable in the localities in which it originated and, notwithstanding the fact that it usually expresses weather-signs indirectly, it may often be traced to a logical source. It appears that most of it evolved from the accumulated experiences of years of everyday observation of the sky and the weather. However, the weather-signs differ somewhat in various parts of the world; hence, those sayings which have been transplanted into regions remote from their sources are liable to appear to be merely "rhyme" without the "reason." Nevertheless, it is interesting and worth while to analyze the weather-lore which has been handed down through many generations and to attempt to ascertain its foundations. In other words, it is hardly safe to laugh at the picturesque sayings of the weather-wise layman regardless of their apparent lack of connection with the sky or with other direct weather-signs.

However, meteorologists during the past fifty years have gathered so much scientific data pertaining to the winds, the sky, and barometric pressure, that it is easy to base weather-prognostics upon these facts. This adds another interesting phase to the appreciation of cloudland.

The cyclonic storm and the anticyclone are such important factors in the weather that a brief consideration of them will reveal the portent of many of the weather-signs in the sky. As already indicated, the cyclone is a huge system of winds surrounding a region of low barometric pressure. The weather-maps may show the distribution of pressure, the direction and velocity of the wind, the character of the sky, and the kind of weather in various regions of the cyclone. As one of these storms approaches and passes over a given locality, the sequence of the essential details is more or less as follows: clear sky, cirrus clouds, east wind, denser cirro-stratus, stratus, cumulo-nimbus, a rainy period, mists, west wind, squalls, final shower, breaking clouds, clear sky.

In the United States the shape of these cyclones is such that the region of low barometer or the storm-center is not in the center of the cyclone. This "low" is usually not as far from the northern and western edges as from the other edges. Inasmuch as these cyclonic storms travel generally from west to east, the sky-signs are farther in advance of the storm-center than to the rear.

Likewise, they extend much farther south than to the north.

If the reader will visualize this cyclonic storm as described in the chapter on "Winds" the changes in the direction of the wind become obvious. In general, the winds are blowing toward the center, although their actual paths may be loosely described as spirals. Before the actual storm-center arrives, the wind is easterly, that is, toward the west and the storm-center. They shift gradually as the storm-center approaches and finally after it passes, the winds are westerly, though still toward the storm-center. The actual directions during this shift depend somewhat upon whether the storm-center passes directly over or to one side or the other of the observer's locality.

As has been mentioned several times in other chapters, the cirrus clouds are formed by the moist air drawn into the storm-center and projected to high altitudes where the moisture condenses. The high westerly winds of those upper regions, from four to seven miles above the sea-level, carry these filmy cirri far in advance of the storm-center and they become weather-signs for the cloud-wise. They foretell the approach of the storm and only fail when the storm wears out or shifts its course radically from the general course of such storms.

But there are various forms of cirrus clouds, some of which are fair-weather and others are foul-weather clouds. There are many forms of

pure hairy cirri which indicate fine weather while others such as "mare's tails," "cat's tails," and "goat's hair" are forerunners of foul weather. In general, rapidly moving upper clouds signify worse weather than those which move more slowly. In some places the "mare's tails" usually indicate approaching wind and "goat's hair" merely rain. "Mare's tails" and "cat's tails" precede the violent cyclonic storms known as hurricanes in the tropics. "Mare's tails" are long straight fibers of gray cirri; "cat's tails" are denser; "goat's hair" is a short bunch of white filmy cirrus fibers. All these are found in the outer areas of a cyclone and after a little experience they will be recognized as being intermediate between the cirrus stripes and the pure filmy veil-like cirri attending fine weather.

Clouds and other weather-signs should be judged with preceding conditions in mind. False cirri may be formed in connection with cumulus clouds and these may be mistaken for the cyclonic cirri. Toward evening thin cirrus-like clouds sometimes appear similar in form to "mare's tails" but these are often decadent cumuli which soon disappear. Foul-weather cirri, which herald the approach of a cyclonic storm, do not disappear after sunset. If these gradually thicken and the barometer steadily falls a storm is not far away. Cirrus clouds precede the storm-center by an interval of from ten to thirty hours. The foregoing illustrates a general principle.

namely, that the same cloud-forms may not always indicate the same kind of weather. A general knowledge of preceding weather and sky conditions and of the formation of clouds is necessary if the weather is to be foretold with a fair degree of accuracy.

Wisps of thin cirri are formed in fine weather by condensation in ascending air. Owing to the low humidity during fine weather and the less forceful ascension of air, these fair-weather cirri are very thin and wispy. The foul-weather cirri which are born in the cradle of the storm are generally denser and are likely to consist of longer streamers crossing the entire sky.

The thin layer of cirro-stratus soon follows the first appearance of foul-weather cirrus. This may be considered merely a thickened layer of cirri nearer the storm-center. It is this thin fog of ice crystals at altitudes of five or six miles which is responsible for a "watery" sun or moon and for halos. The latter generally appear before the former in the cyclonic cycle of events. The portent of the halo has been incorporated in weather-lore in many ways, an example of which is,—

> "Last night the moon had a silvery ring
> Tonight no moon we see."

Continuing toward the storm-center, fine rain is next encountered which soon becomes driving rain. In the storm-center squalls and heavy

showers are common and, of course, there always comes the clearing shower.

"When rise begins after low,
Squalls expect and clear blow."

As the center passes, the sky is full of broken clouds and the rear of the storm is characterized by cool dry air and a blue sky with well-defined cumulus clouds. The conditions of the rear are quite the opposite of those of the front of the storm. In front the clouds appear generally stratified but in the rear they are generally cumuli with a clear blue sky above. Cirrus clouds do not often appear in the rear of the cyclone. The "mare's tails" and long wispy cirri often appear to the south of the center and indicate wind rather than rain.

The corona is formed by the diffraction of sunlight usually in alto-stratus cloud which is at an altitude between two and three miles. The corona exhibits the colors of the rainbow with blue inside and red outside. If conditions are right, a corona will be seen in advance of the cyclone. The halo is a phenomenon of the ice crystals of the cirro-stratus ordinarily at twice the elevation of the alto-stratus. It usually is followed by rain within twenty-four hours. A corona may be formed when any thin cloud of water particles passes between the observer and the sun or moon. Apparently the smaller the particles of the cloud,

the larger the corona, consequently, if the diameter of the corona rapidly grows smaller and the clouds denser, the storm is rapidly approaching. Mock-suns or mock-moons are caused by the intersection of halos and are merely brighter spots due to the reinforcement of one halo at this point by the brightness of the intersecting halo. Sometimes the halos are too faint to be seen, but the mock-suns or sun-dogs may be visible.

The anticyclone is in many respects the antithesis of the cyclone. It is the system surrounding a barometric "high" and the air is calm and cold in this central region. In the outskirts the wind blows clockwise around the center and spirally outward as seen in an imaginary bird's-eye view as on a weather map. The direction of the air-currents is such as to bring the cold air from high altitudes down to the surface of the earth, hence, the regions of "highs" are cooler than "lows." The anticyclone is often comparatively stationary for many days while the cyclone generally moves steadily and sometimes fairly rapidly. It is characterized by blue sky with, of course, fair-weather cumulus clouds, by much dew, and often by a hazy horizon, and by mists in the valleys during the night and early morning. No dew after a hot day often foretells rain approaching.

Fleecy cirro-cumulus are often formed near the edges of anticyclones and under these conditions foretell fair weather.

"If woolly fleeces spread the heavenly way
No rain, be sure, disturbs the summer's day."

They are sometimes formed before thunderstorms and under such circumstances, they would not be fair-weather clouds. When occurring in large numbers they form the "mackerel" or "curdled" sky. In weather-lore there is some conflict in regard to the portent of these clouds, but mackerel skies are usually considered to portend approaching rain.

"Mackerel scales and mare's tails
Make lofty ships carry low sails."

Perhaps it is safe to state that no cyclonic foul weather is indicated by woolly cirro-cumuli. If a mackerel sky is followed by a general thickening, precipitation is usually only a few hours distant, but if the scales diminish in size and disappear, or nearly so, dry weather is generally assured. Cirro-cumuli sometimes develop into strato-cumuli, but despite the general suspicion with which stratus clouds should be viewed, strato-cumuli do not bring precipitation.

Clouds may appear very dark and foreboding but as long as they are broken, there will be little or no precipitation. This darkness is caused by the great thickness through which little of the sunlight illuminating their upper surfaces is able to penetrate. When these coalesce into a uniform

sheet and grow gray, rain or snow is usually approaching. Little need be said of the nimbus clouds because rain or snow is falling from them and the weather is obvious. If the sky is lighter beyond them, the rain or snow is likely to be of short duration.

Local weather conditions are quite varied owing to local influences but sky-signs are usually plentiful and reliable. However, the details of such weather may be best studied by observation fortified by a knowledge of the details of general storms. This phase of weather becomes exceedingly obvious to the aerial traveler. For example, during a dry spell when there is not enough moisture in the air from which cumulus clouds may form over wide areas, it is not unusual to look down upon clouds floating over woods, river valleys, and swampy regions with no clouds appearing elsewhere. The local variations of weather conditions and of the appearance of clouds very soon impress the observant cross-country traveler in cloudland. The details of local conditions cannot be adequately discussed within the boundaries of a single chapter, therefore, they will be left to each interested reader to observe and to analyze in his own locality. It should be noted that local variations are usually merely a matter of intensity and that principles remain fairly definite and universal over the entire globe. Superposed on the general and local storms or weather, there are always the diurnal

weather conditions. Today one of these may dominate, tomorrow, another, but local or diurnal conditions can hardly convert the foul-weather cirrus into the fair-weather cumulus clouds.

The sky displays the effects of the seasons. During dry weather months in some regions only blue sky is seen in the rear of a cyclone because there is not enough moisture to form cumuli; however, in damp localities the cumuli may be formed in all seasons, though they may be denser in summer than in winter. It is perhaps commonly observed that similar weather is experienced about the same time every year. This does not appear strange when the seasonal variation of winds, for example, is considered. In fact, the word "monsoon" is derived from an Arabic word meaning "season." However, the seasonal variation of weather is not sufficiently alike from year to year to warrant the compilation of daily weather charts and prognostics a year in advance. Furthermore, there are still too many complex influences which are not thoroughly correlated at present, to trust a year in advance to statistical averages. Possibly in the distant future the meteorological web will be so completely untangled that the weather may be prophesied a year in advance, but a day or two is the safe limit at present. In fact, these are further reasons for observing the sky-signs from day to day; furthermore, the sky foretells weather sometimes in advance of the barometer.

In the doldrums, where calms may endure for weeks, the sky is of a hazy white color, occasionally becoming uniformly gloomy but remaining cloudless. At other times small patches of cumuli appear. In the trades the sky is usually strewn with small detached cumuli floating high.

A complete discussion of the relation of sky-signs to the weather would be extensive and could not be presented without extensive tedious qualifications, therefore in the foregoing paragraphs some general aspects have been discussed. The reader who is already interested or who plans to absorb some of the interest in the sky, whether from the earthly world or the aerial one, will find it easy to obtain much experience in reading the sky-signs as a by-product of his observations. The clouds cannot alone be depended upon always. Their origin and meaning, however, are usually evident if preceding weather and conditions of the sky have been noted. These combined observations will aid in developing accuracy in weather forecasting. By all means, the beginner should observe daily if possible the charts issued by the Weather Bureau. These, reinforced by observations of the sky, will make for proficiency. This aspect of the sky as well as the others treated in various chapters supply just so much more of interest along the highway of life.

A few brief statements, devoid of their qualifications, which would be tedious to read, may be of interest.

Cumulus clouds are likely to be fair-weather clouds if they are small, harsh, and high. When they grow large and dark, showers should not come as a surprise.

"When clouds appear like rocks and towers
The earth's refreshed by frequent showers."

If huge ranges of cumuli lie beyond in the direction of the wind, a heavy storm is probable.

The details of the thunderstorm have been presented in other chapters.

When clouds of various levels are moving in different directions there is obviously an unsettled state. Rain or snow may follow but often this is a condition preceding the close of a cyclonic storm.

Huge cumulus clouds against a blue sky sometimes in winter are responsible for snow flurries after which a period of clear cold weather sets in.

Turbulent clouds obviously indicate violent gusty winds, and squalls may be looked for in proper season.

Cloudy nights are warmer than clear ones.

The cloudless sky will yield various signs to the experienced observer. Its color and haziness in conjunction with the preceding clouds and other conditions should be observed and the resulting weather noted.

Continued fair weather generally follows: if cumulus clouds decrease toward evening; if cirrus

clouds disappear; if clouds rise on mountains; if the sun sets in a cloudless sky; if myriads of stars are visible; if the wind is gentle and westerly.

"A rainbow in the morning
Is the shepherd's warning;
But a rainbow at night
Is the shepherd's delight."

In the former case there is a bank of cloud and rain to the west, but in the latter case the sun has broken through and indicates a clearing.

Foul weather is generally approaching: if cirrus clouds appear well-defined and extend across the sky from the west; if cirrus develop into cirro-stratus clouds; if scuds are drifting from east to west; if a ring surrounds sun or moon; if stars are indistinct; if clouds gather or lower upon mountain peaks; if the sun is gradually obscured by clouds.

There will be precipitation: shortly after cumulus clouds darken and show trailing showers; several hours after the sun or moon has been blotted out by cirro-stratus; in from ten to thirty hours after the first foul-weather cirri appear; shortly after a thunder-cloud appears on the west wind; an hour or more after a thunder-cloud appears with an east or southeast wind.

There will be a clearing if the clouds rise and break up and the wind shifts toward the west.

The temperature will decrease if the sky clears up toward nightfall.

Of course, winds play a dominating part in the weather and in weather forecasting. Their course is determined by the direction in which the clouds are moving with more certainty generally than at the surface of the earth. Westerly winds mean fair weather; a shift to the south or to the northeast indicates the approach of foul weather; a shift from easterly to westerly indicates a clearing.

At best, the foregoing is only a brief introduction to the extensive phase of the sky as a weather-indicator, but it should be helpful to the earthly observer and to the aerial traveler if he wishes to become weather-wise. Those who are content to be admirers of the sky without considering its utility may find that a general appreciation of the utility of the sky may intensify its beauty as well.

CHAPTER XXI

THE CONVOY

"And when the stream
Which overflowed the soul had passed away,
A consciousness remained that it had left,
Deposited upon the silent shore
Of memory, images and precious thoughts,
That shall not die, and cannot be destroyed."

—WORDSWORTH.

CLOUDLAND is versatile. It is a fairyland of beauties and wonders which awaken admiration and awe. It is a dreamland of inspiring panoramas and awesome spectacles which challenge the senses. It is moody and reflects the intent and action of Nature. It has enslaved poets of all ages and its infinitude lends wings to the imagination. It has helped to make this globe inhabitable by bringing rain and by screening the earth from the burning rays of the untempered sun of space. All these functions it has performed unasked, unaided, and uncontrolled until, in general, man in his growing independence has become indifferent to its beauty, its wonders, and even its utility.

But cloudland has become a highway of travel, and as man takes to the air the novelty will set his senses keenly alert. His nascent condition may give cloudland its great opportunity for captivating his interest and admiration. Aerial travel is a superb achievement which has expanded the world and the experiences which it affords will not be quickly exhausted. However, they will not be adequately described until poets have flown for ages through cloudland.

With all that is ahead it may seem unnecessary to look back; still certain cherished memories linger behind which will always glow despite the experiences to come. And the immortal glow of a cherished memory so often colors the experiences and gives to them a fuller significance. In this little volume the recent war has not been mentioned except to credit it with vastly hastening the realization of man's mastery of the air. An attempt has been made to describe the delights of air-travel and the facts of the aerial world as they will always be.

During the war numberless aerial experiences were accumulated. Most of them were colored by the awfulness of warfare. Men braved the dangers of the air at the front, fought gallantly and unselfishly, and performed wonderful deeds worthy of high places in the traditions of the peoples for whom they fought. But such deeds are for the annals of war. Worthy as they are, they have no logical place in this little volume.

Still the mastery of the air doubtless will be associated for many years to come with the terrible strife which developed the airplane so rapidly from a doubtful infancy to its present confident and successful youth. War is a bloody blot which should be forgotten but its lessons should be remembered and the memory of its victims and heroes should be reverently cherished.

The glory won by aircraft in war has been adequately recorded in the annals of the recent conflict but it is difficult to close without adding a note reminiscent of the service which aircraft have rendered and of their meteoric development. A certain event appears to supply this note without introducing the terrible side of warfare. Furthermore, this event has a broader significance, for it not only pictures the remarkable development of the airplane from a hazardous plaything to a mighty conqueror of the air but it also symbolizes a nation unified in its unselfish mission.

It was a midsummer's morning on the Atlantic coast and those who were abroad on the bay at daybreak saw many dim shadowy hulks outlined in the dawn against the brightening sky over the watery horizon framed in the gateway to the ocean. Several hours later at the naval air-station the usual routine activity was augmented, but owing to the nature of the business at hand, a knowledge of it reposed only in the minds of a few superior officers. Two gigantic flying-boats

were roaring eagerly as they were being warmed up for their continuous all-day patrol. They weighed many tons and the spread of their wings dwarfed all ordinary airplanes into insignificant pigmies. Fuel by the ton was being poured into their depths. They bristled with the accoutrements of war and the crew of six men was comfortably quartered with room for many more. These huge flying-machines with a cruising range of a thousand miles and a net lifting force of several tons, had evolved under the stress of war from the weakest infancy in less than four years. As they roared in their majestic confidence amid their surroundings, which bore all the earmarks of hurried construction, they symbolized the power of knowledge if commandeered and directed to the utmost.

Suddenly the impatient roar of the motors diminished and one of the huge craft slid easily into the water to ride the gentle swells with purring motors suggestive of a contented water-fowl. A few moments later its mate took to the water with the same air of satisfaction. After a little maneuvering everything seemed to be in readiness for the pair to start on an aerial cruise which, barring mishaps, would be at least an eight-hour patrol. The motors of one of them increased to a terrific roar as the craft gained speed down the great harbor. It showered spray as it plowed through the surface of the water. The white spray grew less as the depth of the furrow de-

creased and soon the forward observer became conscious that the surface of the water was receding downward. Straight for a battleship the huge craft flew as though bent on a mission of destruction, but the grotesquely painted man-of-war passed underneath by a safe margin.

How intimate one felt with the vessels glistening upon the water below! With a safe landing surface on all sides the crew of a flying-boat may be intimate with the water's surface, but not so for those who fly over the harbor in airplanes. An occasional dip in an airplane in order to pass close to the bow or stern of a cruiser and to wave to the "jackies" is a thrilling and suspended moment for the occupant of an airplane. But this huge flying-boat with wings spread considerably more than a hundred feet, was intimate with the vessels because it is as much at home on water as in the air. Describing a huge arc this super-aircraft made for the bay and once over the bay it curved again toward the gateway to the ocean twenty miles away.

At an altitude of a few hundred feet in a stable flying-boat one enjoys comforts not afforded in the small high-flying airplanes. Besides, there is novelty in the security of this low altitude in a flying-boat because airplanes must go high for safety. At an altitude of a thousand feet or more the details of the harbor, the bay, and the gateway to the ocean are visible for many miles. Steadily the coast-line draws near and the mine-

sweepers and patrol boats are seen on duty at the gateway. Passing over this junction of ocean and its inland arm, the details of the submarine net are visible below.

The huge aircraft is now over the dark blue-green Atlantic Ocean and heads for the eastern horizon. As the observer notes the coast-line being left behind at the rate of seventy-five knots per hour, he turns unconsciously to look back for the mate of the craft. There it comes, on the same course, a small speck to the west. Down below on one side is a tramp schooner with brilliant white sails distended in a fine breeze. On the other side four small freighters are abreast. "In company there is strength" seems to be the motto in the waters below, for submarines are abroad in this region where the highways of the sea converge. Are those small cigar-shaped objects sharks? They must be, for the sharks are in this region this summer.

The observer in the prow of this huge flying-boat is busy, for there is so much to see and to feel. All about him above and below, there is much of interest, for up to this time few persons have been abroad in this aerial world over the Atlantic and headed east for a day's cruise for the most part out of sight of land. He looks back in admiration upon the mechanism weighing several tons which not only supports itself by its own power but carries him and several tons of men and equipment. As he looks backward he

sees a pair of heads projecting above the curved back of the hull. They are the stalwart pilots who guide the craft. Still farther back, perhaps thirty feet, is a cabin from which huge wings spread laterally. Out upon one of these wings stands a human being with leg twisted round a strut, tinkering with a piece of the mechanism.

During this time the craft has curved in a great arc and the observer is suddenly surprised to see the craft's mate come alongside. They cruise side by side for some time, then the mate veers off as if bent upon some mission. As it dwindles in the distance the observer seats himself in the cockpit out of the terrific wind and reflects upon the wonders of flying. In his notebook he jots down the things he has seen and attempts to describe his feelings. The situation impresses him with the same unreality that he felt in the polar regions four miles above or far out on the aerial highway in a cross-country flight.

Minutes pass as his psychological being tries to digest and to assimilate the impressions of the past half-hour. Down in this cock-pit with only the sky visible of all the infinitude of space and area which surrounds him, his thoughts wander back a score of years to the advent of the first automobile. Then back a century to the first steamboat and then to the intrepid explorer who sailed out from the east to discover the continent which is now disappearing in the western haze. In the course of a few moments his thoughts scan

the entire development of travel and he sees in his mind's eye the epochal achievements of the past. But how progress has accelerated until achievements have become massed in the present century! Surely it is wonderful to live in this age of accumulated and directed knowledge.

But he may reminisce at home without wasting wonderful opportunities of a life-time. He rises to mount his high perch whence his gaze may span almost the entire circle of the horizon. He glances downward over the nose of the craft and becomes transfixed. Down there upon that ruffled blue-green area is a group of more than a score of vessels. They are orderly, grim, and bent upon a purpose. Ahead is the zigzag white wake of the destroyer in the lead. Beyond the outskirts are the busy little submarine chasers. The observer now accounts for the ghostly forms which he saw toward the east at dawn. They comprised this convoy bound for the sea and Europe.

As the huge craft dips downward toward this group of vessels, khaki-clad beings turn their faces upward and wave their caps. To them this crew on wings is a guardian angel whose watchful and penetrating eyes look for the submerged enemy. To the observer this group of silent, grim, speeding vessels with its cargo of men, food, and munitions is the answer of a nation which loves freedom and whose purpose is to aid others against the tyranny of aggression.

The aircraft soars over and beyond for several

miles, then in a huge circle it sweeps the ocean for many miles. Its mate is patrolling a similar area ahead and on the other side. Each hour a circle is described and the aircraft returns to the convoy.

With each bird's-eye view of the convoy steadily steaming eastward in an orderly manner bespeaking a grimness of purpose, the observer's feelings become more definite and vivid. With each intervening hour for reflection the great significance of this group of vessels becomes clearer. They symbolize a nation's unity, its strength, its determination, its grimness of purpose.

All day long the huge aircraft circles far and wide and with each successive return to the group of vessels so tiny upon the vast ocean down below, the convoy is ten miles farther upon its eastward course. The day passes and the sun is low in the west. The aircraft does not head out again in advance of the convoy but circling over it as if reluctant to leave, it finally turns its prow toward the sunset and home. It seems cruel to desert that silent determined group, but Night will soon drop its protecting curtain.

To the west the sun is sinking low upon the watery horizon, for the coast lies beyond the curve of the earth, an hour's flight away. The observer looks back upon the group of vessels rapidly diminishing in the distance. He longs for adequate words for his notebook and wishes that a poet might have witnessed the inspiring sight.

Surely only a poet could do justice to the symbolism of that convoy.

As the aircraft roars toward the west the horizon becomes a roughened line of land cutting the red disk of the sun as it sinks to rest. The sunset is tinged with the sadness of a double farewell—one to Day and one to that group of vessels disappearing into the night at the eastern horizon. For the observer, twilight's curtain is closing the fullest day of his life. The hollowness and inadequacy of words mock him as he reads these lines in his notebook,—

THE CONVOY

Far below, furrowing the sea,
A score of ships with purpose grim
Sent forth to curb War's cruel whim,
You symbolize our unity.
To enemy of liberty
You bear the cup filled to its brim
With dark despair. Our eyes grow dim
With pride as you steam eastwardly.

We soar above and watch below
With eyes which pierce with greater sight
The depths where lurk determined foe.
But tired wings must soon alight.
Godspeed! We turn toward sunset glow
While you steam on into the night.